

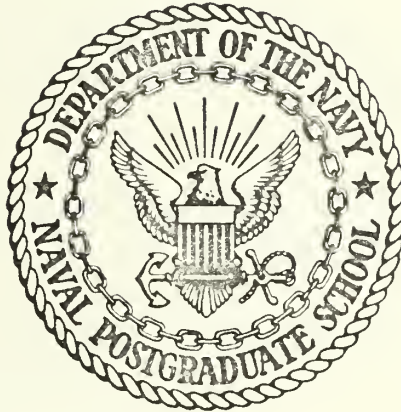
A QUEUING MODEL SIMULATION
WITH DYNAMIC GRAPHICAL DISPLAY

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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

A QUEUING MODEL SIMULATION
WITH DYNAMIC GRAPHICAL DISPLAY

by

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Thesis Advisor:

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March 1973

Approved for public release; distribution unlimited.

T153548

A Queuing Model Simulation
with Dynamic Graphical Display

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1973

ABSTRACT

The purpose of this thesis is to provide the student of queuing systems with a vehicle through which a better understanding of the interrelationships between stochastic processes and queuing systems can be achieved.

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ACKNOWLEDGEMENTS

The Hybrid Computer at the Naval Postgraduate School is a self-operated system; because many of the complexities of the system were unfamiliar to the programmer, the technical assistance of Mr. R. Limes, Mr. W. Thomas, and Mr. A. Wong was invaluable.

I. INTRODUCTION

A queuing system is comprised of action facilities (servers) and waiting facilities (queues or lines). The relationship between the components can be of many forms, each with their own characteristics. Consider a tool crib in a machine shop where the machinists are obliged to check out their tools; or consider the telephone system, in which callers request communication capacity. Both situations involve requests for action from limited resources, in these cases, servers or telephone circuits. In order to allocate resources properly, it is necessary to understand the interaction between requests for action and the actions themselves. Individually these can be modeled as stochastic processes, but in order to predict flow through the queuing system, it is necessary to understand the interrelation between the patterns of event occurrences. When demands occur at regular intervals and actions are of fixed duration, it is relatively easy to predict flow; if there are more requests per unit of time than actions over the same time span, the queue will grow without bound unless the event relationship is changed. When variation is added to the timing of events, the flow is not as obvious. For example, if the average number of requests for action equals the average number of actions, per unit of time, but both occur with variability, then it would be useful to be able to predict such quantities as expected delay and action

facility idle time. Queuing models are used for this purpose.

The purpose of this thesis is to provide the student of queuing systems with a vehicle through which a better understanding of the interrelationships between stochastic processes and queuing systems can be achieved.

This is done through a combination of a computer simulation and a computer-driven graphical display.

II. QUEUEING MODEL SIMULATION

This computer program simulates queueing systems in two stages. First, a next-event type computer simulation creates a time history of the queueing system. Second, a dynamic graphical display depicts the occurrence of the queueing process in real time.

Five basic, academically interesting, queueing models, each with parameter options, can be simulated. Queueing models are generally described in terms of the distribution of request occurrences (arrival distribution), the distribution of action occurrences (service distribution), and the number of action facilities (servers). Specifically, the times between request occurrences are taken to be independent and identically distributed realizations from the arrival distribution. The duration of each action occurrence is also taken to be an independent and identically distributed realization from the service distribution. Variations on these assumptions occur for some models and are described in Section A.

The abbreviation G/G/C describes a queueing system in which the arrival and service distributions are general (unspecified) and there are C servers.

The five options in this simulation are:

- (1) G/G/C
- (2) G/G/C with losses
- (3) G/G/C with feedback

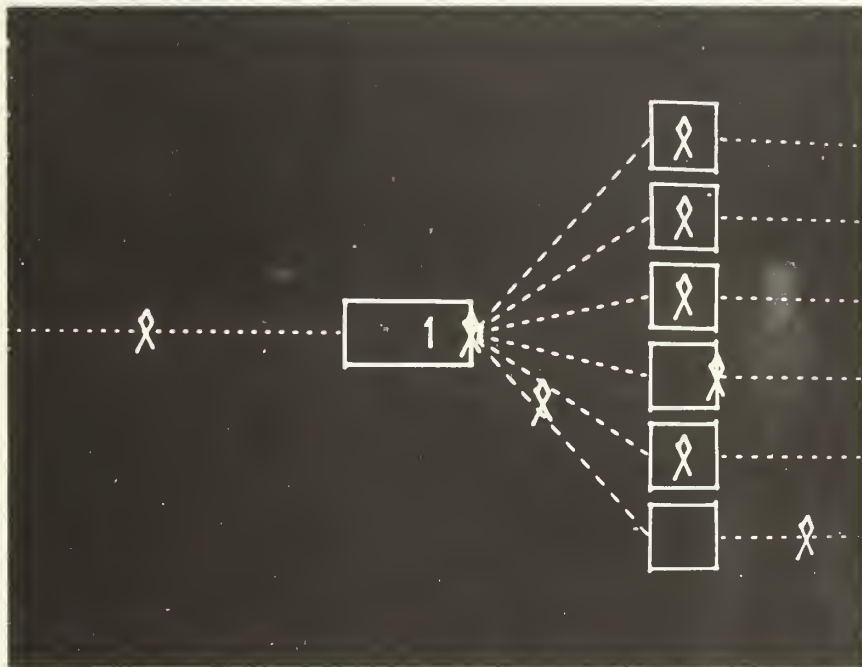
(4) G/G/C with finite source

(5) Two simultaneous G/G/C queues for comparison.

The specific choices of arrival distribution and service distribution which can be simulated are fully described in Section B.

A. THE QUEUING MODELS

1. G/G/C

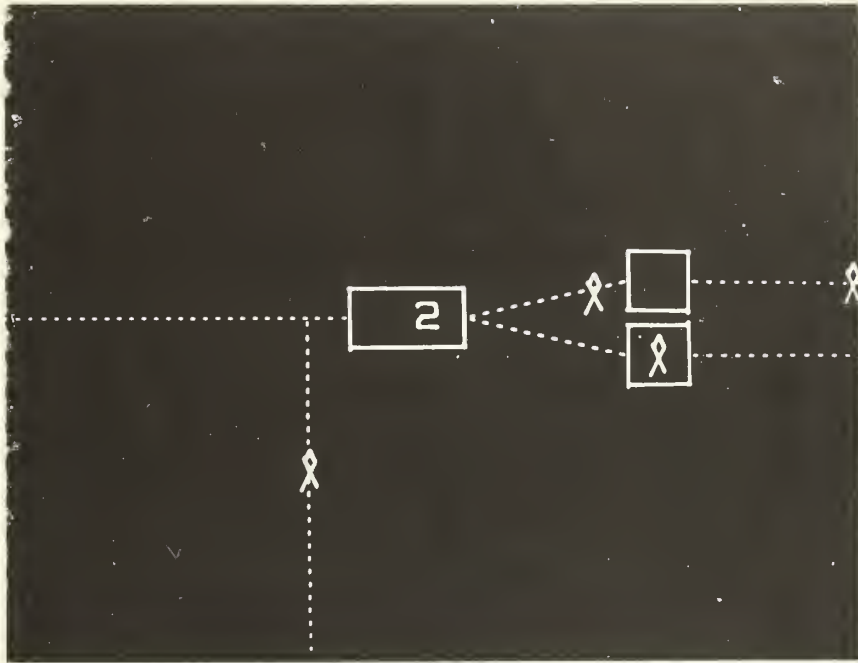


Picture 1

This is the simplest of the queuing models considered here. Each arrival waits in the queue until a server is available, enters service for a calculated period of time, then departs the system.

This model may be simulated with from one to six servers.

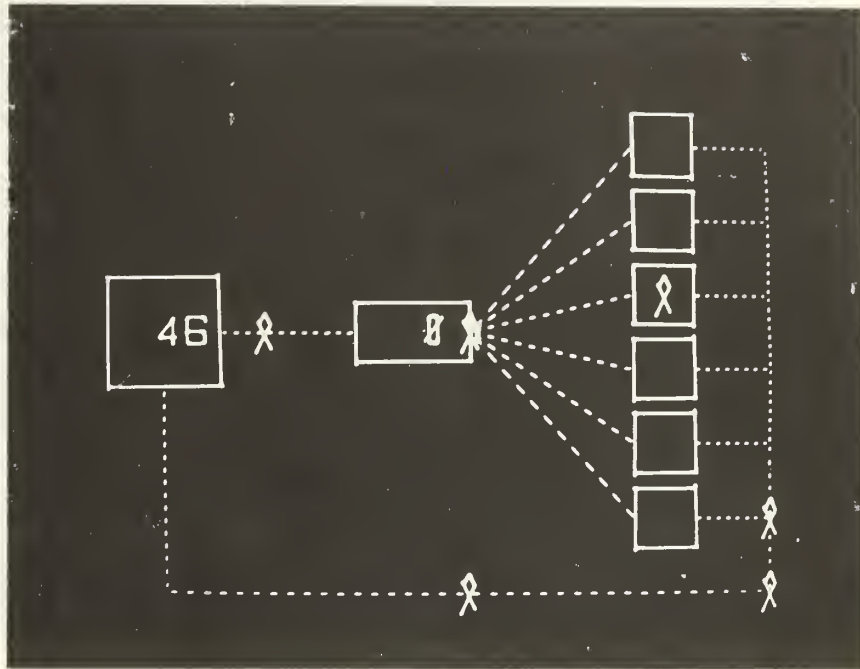
2. G/G/C with Losses



Picture 2

Consider making a long distance telephone call on Mother's Day. If all the trunk lines are busy, your request for service will be rejected. The G/G/C model with losses reflects this by rejecting arrivals who find the queue full. The queue limit used is specified as an input parameter. Note that rejected arrivals are lost and are not assumed to return later. The fraction of all arrivals who are served (not rejected) is recorded for subsequent display.

3. G/G/C with Finite Source

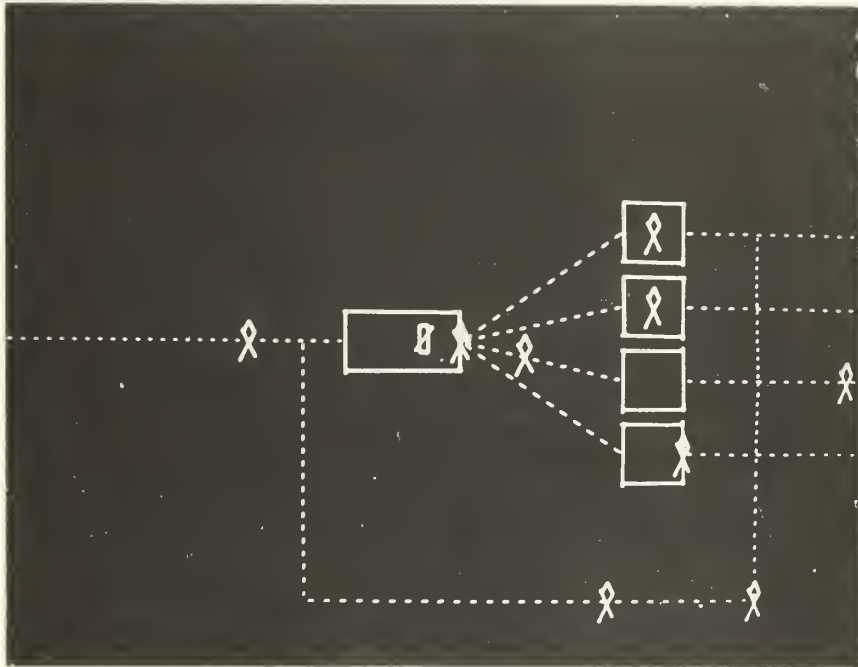


Picture 3

Consider a closed-circuit educational television system at a school. The finite population consists of all the televisions in the system. When one fails, it enters the queue to be serviced. After repair, it re-enters the population pending the next failure.

This situation is modeled by assuming that each action source, upon entering the idle population, is assigned a waiting time from the arrival distribution. When this time expires, the source requests service, joining the queue if necessary. As each action source terminates its service, it returns to the idle population. The user specifies the number of servers (one to six) and the size of the population.

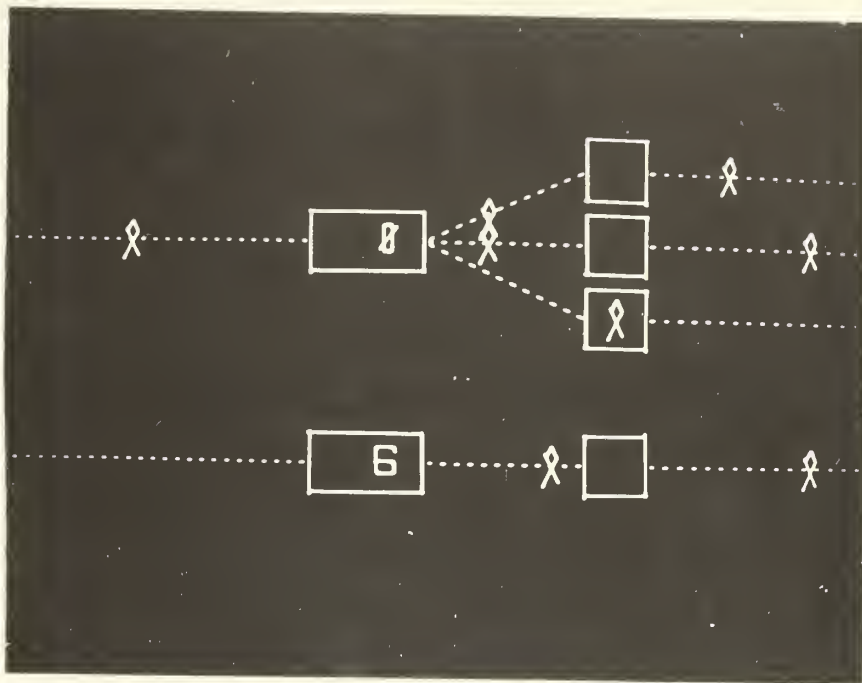
4. G/G/C with Feedback to the Queue



Picture 4

This is an extension of the G/G/C model, with from one to six servers, allowing customers leaving service to depart the system or to return to the queue. At each service completion, the customer leaves the system with probability P or returns to the queue with probability $1-P$. The user specifies P as an input option.

5. Two Simultaneous G/G/C Queues



Picture 5

This option allows comparison of two standard G/G/C queues, each with up to three servers. All parameters of each system are specified separately, and, if desired, identical arrival streams may be utilized. This allows comparisons between different arrival and/or service distributions and associated parameters, and between a different number of servers. Also, the effect of the various queuing disciplines can be compared.

B. ARRIVAL/SERVICE DISTRIBUTIONS AND QUEUE DISCIPLINES

As well as options already described, the following arrival and service distributions are available to the user of the program. Any of the following probability

distributions can be used as an arrival or service distribution.

1. Distributions

a. K - ERLANG (exponential when K=1)

$$F(t) = 1 - \sum_{J=0}^{K-1} \frac{(\beta t)^J}{J!} e^{-\beta t}$$

$$\text{RATE } \lambda = \frac{\beta}{K}$$

$$CV = \frac{1}{\sqrt{K}}$$

Input parameters are:

(1) K

(2) Rate - in terms of mean number of events per minute.

b. Hyperexponential

$$F(t) = p(1 - e^{-\lambda_1 t}) + q(1 - e^{-\lambda_2 t})$$

where:

$$(1) p + q = 1$$

$$(2) CV = \frac{1}{\sqrt{p}}$$

(3) λ = Rate is specified and then

λ_1, λ_2 chosen to satisfy--

$$\lambda_2 = (2 + \sqrt{2})\lambda$$

$$\lambda_1 = \left(\frac{p(2 + \sqrt{2})}{2 + \sqrt{2} - q} \right) \lambda$$

Input parameters are:

- (1) Rate, specified in terms of mean number of events per minute.
- (2) Coefficient of variation (must be greater than 1.0)

c. Degenerate (Fixed Rate)

$$F(t) = \begin{cases} 0 & t < 1/\lambda \\ 1 & t \geq 1/\lambda \end{cases}$$

Input parameter:

- (1) Rate λ specified in terms of mean number of events per minute.

2. Queuing Disciplines

For comparison purposes, there are four queuing disciplines to choose from. These determine the priority by which members of the queue will enter service.

a. FIFO - the first into queue is the first out. Over all disciplines which are independent of service times, this one minimizes the variance of delay.

b. LIFO - the last into the queue is the first out. Some systems, by their nature, function in this manner.

c. SSTF - the queue member with shortest service time is served first; this minimizes the mean delay over

all other disciplines, but the variance of delay is greater than that of FIFO.

d. RANDOM DRAW - applies to a system in which insufficient information is known to implement any other discipline.

3. Length of the Simulation

The period of simulation is specified in minutes by the user. All queues are empty and servers idle at the start of the simulation.

III. THE METHOD

A. THE COMPUTER SIMULATION

The computer simulation is a modified next event type. There are two types of events, arrivals to the queue and a completion of service. With the first there will be an associated entry to service if there is an idle server, and with the last an associated entry to service if the queue is not empty.

The simulation is begun with the generation of the first arrival time and its associated service time. The times are generated via the transformation of random numbers to stochastic variates of the type specified. At the occurrence of an arrival, the next arrival time and associated service time are generated. When a server is available, a waiting member of the queue enters service with completion time equal to the sum of his assigned service time and the time he departs the queue. Thus with the clock starting at zero, a time history of events is created which tells what happened and when.

At the same time, the appropriate values are retained from which statistics of the simulation can later be calculated.

B. THE GRAPHICAL DISPLAY

At the completion of the simulation phase, the time history is depicted dynamically on the cathode ray tube

in real time. Pictures 1 to 5 show the form of the display, with the man-like images in motion along the appropriate path, and the number in the queue box showing the queue's current length.

The timing and motion of the display are controlled by the analog computer via the hybrid connections to the digital computer. The first connection is for the purpose of timing until the next event is to be initiated. In this case, the analog computer integrates from zero to a preset time value in volts, at the rate of one volt per second. The interrupt to the appropriate subroutine then occurs, and the analog computer is reset with the next time value, after which the integration is reinitiated.

The second connection causes the dynamic motion to occur by continually checking events in progress and causing the position of the corresponding images to be incremented appropriately; this interrogation and incrementation occurs approximately 10 times per second depending on the settings of the analog computer. Movement increments are between one-half inch and two inches (depending on the path), causing a motion of between five inches and 20 inches per second.

IV. STATISTICS FROM THE SIMULATION

STATISTICS					
	D1	D2		D1	D2
DT	.58	3.98	DC	.31	3.67
BT	2.31	.95	BC	2.27	2.33
LT	2.88	4.94	LC	2.58	6.88
DC	1.15	22.24	DV	5.65	111.86
SC	5.32	2.48	SV	26.59	11.27
WC	6.47	24.63	OV	3.67	38.14
DM	5.88	57.88	OM	3.88	9.88
D8	.58	.92	OS	.35	.81
DX	.46	.92	OL	.14	.76
NC	26	24	PL	.88	
ENTER 1. CONTINUE					
2. PARAMETER LISTING					

At the end of the simulation period, the following statistics are calculated and displayed, as shown above.

AT = time - average length of the queue

BT = time - average number of busy servers

LT = time - average number in the system = QT + BT

QC = customer - average length of the queue

BC = customer - average number of busy servers

LC = customer - average number in the system = QC + BC

DC = customer - average delay in the queue

SC = customer - average service time

WC = customer - average wait in the system = DC + SC

DM = maximum delay experienced by any customer

DO = probability that a customer's delay is greater than zero.

DX = probability that a customer's delay is greater than XD. (The value of XD is an input option.)

QM = maximum queue length reached during the simulation

QO = probability that the queue length will be greater than zero.

QL = probability that queue length will be greater than LQ (the value of LQ is an input option).

DV = standard deviation of the delay in queue

SV = standard deviation of the service times

QV = standard deviation of the queue length

NC = total number of arrivals

PS = percentage not lost (losses model only)

V. PARAMETER INPUT

	ITYPE	5	RUNTIME	1.88
	IC	3	IC1	1
	1	2	3	4
IDIST	1	1	1	1
KK	1	1	1	1
RATE	38.88	38.88	14.88	14.88
CV	1.88	1.88	1.88	1.88
IDSPLN	1	1		
	LD	1	MAXD	1
	XD	1.88	NPOP	1
	IDUAL	1	P	1.88
ENTER 1. CONTINUE				
2. STATISTICS				

Picture 7

Parameters can be input by the card reader or by the teletype terminal. In either case, the namelist form is used, where the entry form is NAME = X, NAME being the variable title and X being the value being assigned. For real variables, the decimal point must be entered. Namelist input is terminated with a *.

A. SAMPLE INPUT CARD

```
IDEV = 2, ITYPE = 3, RATE(2) = 3.0 *
```


B. NAMELIST INPUT VIA THE GRAPHICS TERMINAL

If this mode of entry is specified, one variable at a time is entered, followed by a carriage return. Entries are displayed, as entered, on the graphics screen. Termination occurs with the entry of a * followed by a carriage return.

C. INPUT VARIABLES

The following conventions are employed for specifying the options and parameters to be used.

ITYPE = 1 gives G/G/C

2 gives G/G/C with losses

3 gives G/G/C with finite source

4 gives G/G/C with feedback

5 gives two simultaneous G/G/C queues

RUNTIME = desired length of simulation (minutes)

IC = number of servers for queue 1

IC1 = number of servers for queue 2 (only applicable if
ITYPE = 5 is chosen)

IDIST(I) = 1. K - ERLANG

2. HYPEREXPONENTIAL

3. DEGENERATE

KK(I) = K in K-ERLANG (use K=1 for exponential)

RATE(I) = Rate in number per minute

CV(I) = Coefficient of variation (specify for IDIST(I) = 2
only. This variable is computed otherwise.)

where I = 1 for arrivals to queue 1 (except finite model)
2 for arrivals to queue 2 or finite population
idle parameters
3 for service for queue 1 (except finite model)
4 for service for queue 2 or finite population
service parameters

IDSPLN(I) = 1. FIFO
2. LIFO
3. Shortest service time first
4. Random draw

where I = 1 for queue 1
2 for queue 2

LQ = parameter in the statistic $P(Q > LQ)$

XD = parameter in the statistic $P(\text{wait} > XD)$

IDUAL = 0. Independent arrival streams

1. Identical arrival streams
(applicable to ITYPE = 5 only)

MAXQ = maximum queue size (for G/G/C with losses only)

NPOP = population size (for finite source option only)

P = completion probability (for feedback option only)

VI. THE PROGRAM

The program requires the use of the XDS 9300 digital computer, the CI 5000 analog computer, and a graphics terminal using the GATED monitor.

The analog computer wiring diagram necessary to drive the display sequence appears in APPENDIX A. Before beginning, set Delay Flop Switches DFOO, DFO1, and DFO2 to .1 MS and set counter FOO to 1 and FO4 to 0. Then select RUN and DIGITAL COMPUTER on the analog control panel. This provides for movement interrupts to occur at a rate of 100/11 hertz. If desired, the timing values will be displayed on the RATIOMETER by selecting TRUNK 420 prior to DIGITAL COMPUTER.

The program consists of a FORTRAN program and a META-SYMBOL 9300 program. Because the history is buffered out to the device assigned the logical unit value 7, an additional control card is needed.

Job cards for deck run should be:

⌵JOB

⌵AGT

⌵ASSIGN 7=DF1A

⌵FORTRAN LS,GO

FORTRAN DECK

⌵META 9300 SI,LO,GO

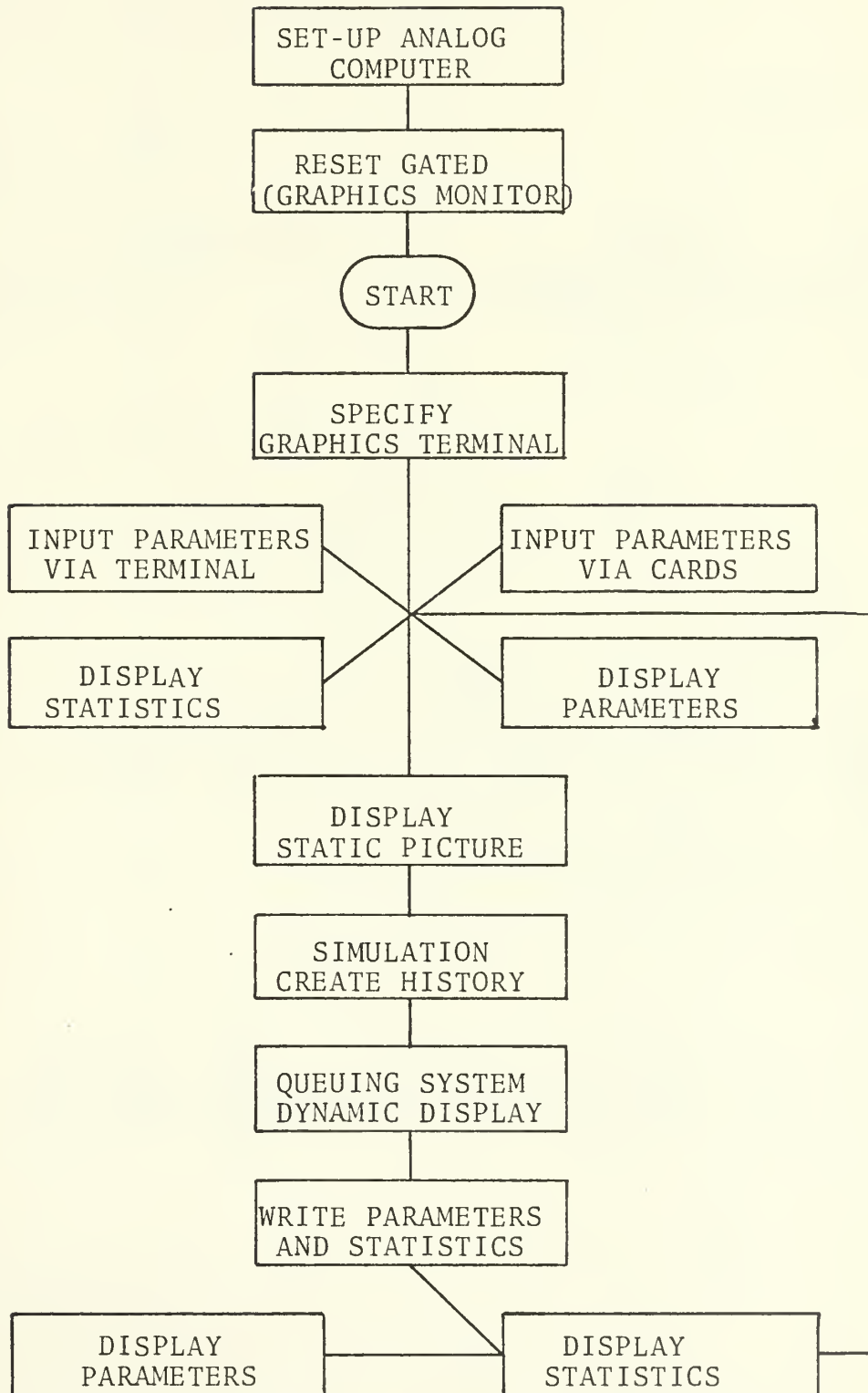
META-SYMBOL DECK

¬EOF

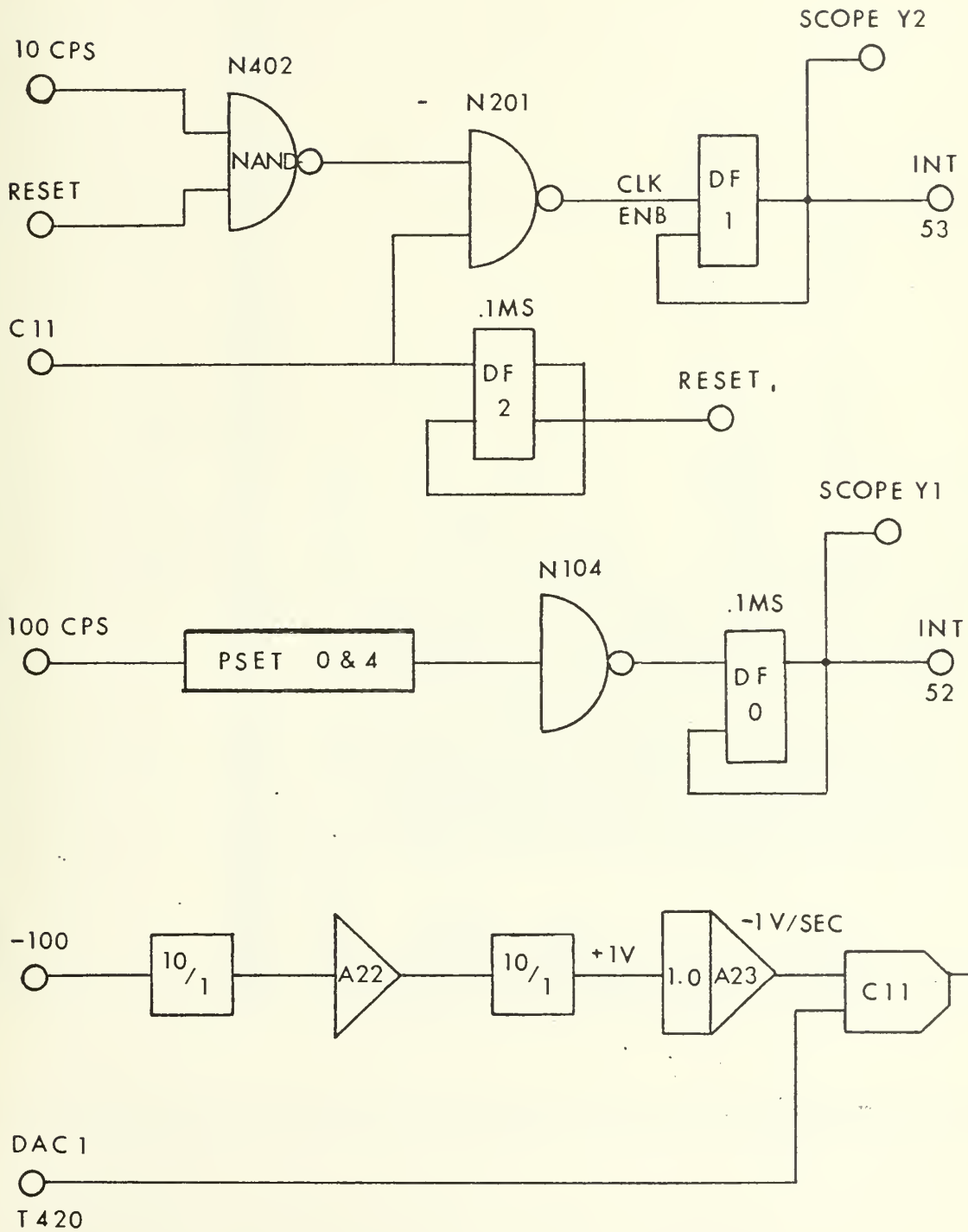
¬LOAD XR,MAP

¬DATA

PROGRAM STEPS



APPENDIX A ANALOG SCHEMATIC



SIMULATION OF QUEUEING MODELS WITH DYNAMIC DISPLAY

C. M. RIDDELL

MARCH 1973

DICTIONARY OF EXOGENOUS VARIABLES

CHNG	-	INCREMENT VALUES	
CLOCK	-	HISTORY TIMES	
CLTIME	-	SERVICE TIME SUM	
CLTIMESQ	-	(SERVICE TIME) ² SUM	
CTIMSQ	-	(QUEUE LENGTH) ² SUM	
CUSTIM	-	QUEUE LENGTH SUM	
CV	-	COEFFICIENT OF VARIATION	
DELAY	-	QUEUE WAIT SUM	
DELAYO	-	DELAYS GREATER THAN 0	
DELAYSQ	-	(QUEUE WAIT) ² SUM	
DELAYX	-	DELAYS GREATER THAN XD	
ENDD	-	MOVEMENT END VALUES	
ETIME	-	NEXT EVENT TIMES	
I3	-	HISTORY POINTER	
IBUFF	-	HISTORY BUFFER	
IBUSY	-	BUSY? 0 - NO; 1 - YES; 2 - NOT APPLICABLE	
IC	-	NUMBER OF SERVERS QUEUE 1	
IC1	-	NUMBER OF SERVERS QUEUE 2	
IDEV	-	SPECIFIES GRAPHICS TERMINAL	
IDIST	-	DISTRIBUTION TYPE	
IDSPLN	-	QUEUE DISCIPLINE	
IDUAL	-	IDENTICAL ARRIVALS? 0 - NO; 1 - YES	
IFDBK	-	FEEDBACK? 0 - NO; 1 - YES	
IFLAG	-	DYNAMIC IMAGE FLAGS	
ILN	-	TEXT LINE NUMBER	
IMAN	-	DYNAMIC IMAGES	
IMD	-	MOVE-DRAW INDICATORS	
IPOS	-	TEXT STARTING POSITION	
ISTDT	-	ARRIVAL BUSY SERVER SUM	


```

C 52 INTERRUPT CAUSES MOTION
C 53 INTERRUPT TIMES EVENTS
C
C CONNECT (52,FLAGS)
C CONNECT (53,SETFLAGS)
C
C DEFAULTS: NO HISTORY OUTPUT; GRAPHICS TERMINAL 1
C
C IPRINT=0; IDEV=1
C OUTPUT(101) TYPE IDEV=2 * AND A C/R IF AGT-2 IS TO BE USED ELSE T
C -TYPE * AND A C/R,
C INPUT(101)
C
C SET THE STATIC IMAGE COORDINATES
C
C CALL PACK
C
C INITIALIZE THE GRAPHICS AND TEXT DIRECTORIES
C
C CALL DGINIT (IDEV,IGDIR,30,IER)
C CALL DTINIT (IDEV,ITDIR,16,IER)
C
C 99 PRESENT MAIN CHOICE PAGE
C
C 110 ENCODE(24,101,ITXA)
C CALL TEXT0 (IDEV,ITXA,6,15,25,2,3,IER)
C ENCODE(24,102,ITXA)
C CALL TEXT0 (IDEV,ITXA,6,17,25,2,3,IER)
C ENCODE(24,104,ITXA)
C CALL TEXT0 (IDEV,ITXA,6,19,25,2,3,IER)
C ENCODE(24,105,ITXA)
C CALL TEXT0 (IDEV,ITXA,6,21,25,2,3,IER)
C ENCODE(24,103,ITXA)
C CALL TEXT0 (IDEV,ITXA,6,24,25,2,3,IER)
C CALL TEXTR (IDEV,NULL,1,26,47,2,3,IER)
C
C WAIT FOR REPLY
C
C 100 IF(MOD(ITDIR(6),8).EQ.0) GO TO 100
C CALL TEXTI (IDEV,1,1,26,47,IER)
C
C LOGICAL RIGHT SHIFT 18 BITS (3 CHARACTERS) DECODES REPLY
C
C I=LRS(1,18)
C
C CALL DTINIT(IDEV,ITDIR,16,IER)
C
C GET CARD INPUT

```



```

C
      IF(I.NE.1) GO TO 113
      INPUT(5)
      DO 114 J=1,4
      IF(IDIST(J).EQ.3) CV(J)=0.0
      IF(IDIST(J).EQ.1) CV(J)=1.0/SQRT(KK(J))
114      GO TO 110
113      IF(I.NE.3) GO TO 112
      IF(I.NE.3) GO TO 112
111      CALL PARAMETERS
      CALL TEXTR (IDEV, NULL, 1, 34, 9, 2, 3, IER)
120      IF(MOD(ITDIR(14), 8).EQ.0) GO TO 120
      CALL TEXTI (IDEV, I, 1, 34, 9, IER)
      CALL DTINIT (IDEV, ITDIR, 16, IER)
      I=LRS(I, 18)
      IF(I.EQ.1) GO TO 110
      IF(I.NE.2) GO TO 111
      CALL STATISTICS
121      CALL TEXTR (IDEV, NULL, 1, 35, 11, 2, 3, IER)
125      IF(MOD(ITDIR(15), 8).EQ.0) GO TO 125
      CALL TEXTI (IDEV, I, 1, 35, 11, IER)
      CALL DTINIT (IDEV, ITDIR, 16, IER)
      I=LRS(I, 18)
      IF(I.EQ.1) GO TO 110
      IF(I.EQ.2) GO TO 111
      GO TO 121
112      IF(I.EQ.4) GO TO 1
      IF(I.NE.2) GO TO 110
      IRLK=1
      GET TERMINAL INPUT
C
C      CALL GINPUT (IDEV, ITDIR, IBLK)
      DO 115 J=1,4
      IF(IDIST(J).EQ.3) CV(J)=0.0
      IF(IDIST(J).EQ.1) CV(J)=1.0/SQRT(KK(J))
115      GO TO 99
C
      CONVERT MINUTES TO SECONDS
C
      DO 2 I=1,4
      RATE(I)=RATE(I)/60.
      RUNTIME=RUNTIME*60
C
      BEGIN MODEL INITIALIZATION OF VALUES
C
      IF(ITYPE.GE.5) GO TO 4
      DO 3 I=1,6

```



```

21 ENDD(5,I)=X(14)+.1
   CHNG(1)=.225; CHNG(2)=.17; CHNG(3)=.205
   NSIM=6
   GO TO 85
C
C
C
   SETUP G/G/C WITH FINITE SOURCE
30 CALL FINITE
   A1=A2=7
   DO 31 I=1,4
31 ENDD(5,I)=X(9)+.03
   DO 32 I=5,10
32 ENDD(1,I)=X(12)
   DO 33 I=11,22
   ENDD(1,I)=X(13)+.1
   ENDD(2,I)=Y(24)-.1
   ENDD(3,I)=X(5)
   ENDD(4,I)=Y(16)
33 CHNG(1)=.12; CHNG(2)=.17; CHNG(3)=.2; CHNG(4)=.275
   NSIM=7
   GO TO 85
C
C
C
   SETUP G/G/C WITH FEEDBACK TO THE QUEUE
40 CALL FEEDBK
   DO 41 I=1,4
41 ENDD(5,I)=X(9)
   DO 42 I=5,10
42 ENDD(1,I)=X(12)
   DO 43 I=11,22
   ENDD(1,I)=X(13)+.1
   ENDD(2,I)=Y(24)-.1
   ENDD(3,I)=X(8)
   ENDD(4,I)=Y(12)
43 ENDD(5,I)=X(14)+.1
   CHNG(1)=.225; CHNG(2)=.17; CHNG(3)=.2; CHNG(4)=.35
   NSIM=7
   GO TO 85
C
C
C
   SETUP TWO G/G/C QUEUES
50 CALL TWOGGC
   ILN(1)=17; ILN(2)=27; IPOS(1)=IPOS(2)=41
   A1=A2=1; A3=5; A4=19
   G1=G2=10; G3=5; G4=19
   S1=S2=12; S3=5; S4=9; S5=2; S6=19; S7=22; S8=15
   DO 51 I=1,4
51 ENDD(5,I)=X(9)

```



```

CALL DTINIT(IDEV,ITDIR,16,IER)
I=LRS(I,18)
IF(I.EQ.1) GO TO 110
IF(I.NE.2) GO TO 91
C
C
C  DISPLAY PARAMETERS?
C
C  93  CALL PARAMETERS
C  175 CALL TEXTR(IDEV,NULL,1,34,9,2,3,IER)
      IF(MOD(ITDIR(14),8).EQ.0) GO TO 175
      CALL TEXTI(IDEV,I,1,34,9,IER)
      CALL DTINIT(IDEV,ITDIR,16,IER)
      I=LRS(I,18)
      IF(I.EQ.2) GO TO 91
      RETURN FOR ANOTHER RUN
C
C
C  GO TO 110
END

```



```

CCCCCCCCCCCC
SUBROUTINE SIMULATE
PURPOSE: TO CREATE THE TIME HISTORY OF EVENTS
AND GATHER STATISTICS
SUBROUTINES USED: ARRIV, BEGSRV, ENDSRV, ACCUM, TIMES

SUBROUTINE SIMULATE
DIMENSION Ibuff(400)
REAL L,LC
COMMON /SET6/ CLOCK(100),KIM(100),LOG(100)
COMMON /SET7/ ETIME(9),I,I3,K1,TIM(115,4)
COMMON /SET8/ CHNG(10),ENDD(5,22),IFLAG(22),ITOT,IPOS(2),XX(5,22),
-ILN(2),IMAN(7,22),NSIM,NQ(2),ITQ(2,2),NPOP,ITPOP(2),XX(5,22),
-XX(5,22),YY(5,22),YY(5,22),IMD(5)
COMMON /SET9/ IDIST(4),RATE(4),KK(4),CV(4),NFDBK,IFDBK,IDSPLN(2),
-IDUAL,IBUSY(6),KP(2),LINE(2),TIME,PSTIME,PTIME(2),RUNTIME,IX1,
-IX2,IX3,IX4,XD,LQ,MAXQ,P
COMMON /SET10/ NTOT,ITYPE
COMMON /SET11/ NCUST(2),MAXLN(2),DELAY(2),DELAYSQ(2),XMDELAY(2),
-DELAYO(2),DELA YX(2),CLTIME(2),CLTIMSQ(2),CUSTIM(2),CTIMSQ(2),
-PROB0(2),PROBL(2),LTOT(2),ISTOT(2)
COMMON /STAT/ QT(2),BT(2),LT(2),QC(2),BC(2),LC(2),
-DC(2),SC(2),WC(2),DM(2),D0(2),DX(2),QM(2),Q0(2),
-QL(2),DV(2),SV(2),QV(2),PL,NC(2)
EQUIVALENCE (IBUFF(1),CLOCK(1)),(IBUFF(201),KIM(1)),
- (IBUFF(301),LOG(1))
I3=1
10 SET EVENT TIMES TO LARGE VALUE
DO 10 K=1,8
ETIME(K)=99999.
IF(ITYPE.NE.3) GO TO 4
I=2
IDLE TIMES FOR FINITE POPULATION
DO 3 J=1,NPOP
CALL TIMES
TIM(KP(1)+1,1)=TIM(KP(2),2)
TIM(KP(1)+1,3)=TIM(KP(2),4)

```



```

C      KP(2)=KP(2)-1
C      SET FIRST ARRIVAL FROM FINITE SOURCE
C
C      ETIME(7)=TIM(KP(1)+1,1)
C      GO TO 5
C
C      GET FIRST ARRIVAL TIME
C
C      4 I=1: CALL TIMES: ETIME(7)=TIM(1,1)
C        IF(ITYPE.EQ.5) I=2: CALL TIMES: ETIME(8)=TIM(1,2)
C
C      SET LENGTH OF SIMULATION
C
C      5 ETIME(9)=RUNTIME
C
C      DETERMINE NEXT EVENT
C
C      11 TIME=ETIME(1)
C      K1=1
C      DO 15 K=2,9
C      IF(ETIME(K).LT.TIME) TIME=ETIME(K): K1=K
C      15 CONTINUE
C
C      SEPARATE END-OF-SERVICE
C
C      IF(K1.GT.6) GO TO 20
C      I=1
C      IF(ITYPE.GE.5 .AND. K1.GE.4) I=2
C      CALL ENDSRV: GO TO 11
C
C      SEPARATE ARRIVALS
C
C      20 IF(K1.LE.8) I=K1-6: CALL ARRIV: GO TO 11
C
C      DONE: COMPLETE HISTORY
C
C      CALL BUFFEROUT(7,1,IBUFF,400,IND)
C      21 IF(IND.EQ.1) GO TO 21
C      GO TO (21,23,22,22) IND
C      22 OUTPUT(101) 'BUFFERING ERROR 5'
C      23 REWIND 7
C      I=1
C      {
C      COMPLETE TIME STATISTICS
C
C      50 CALL ACCUM
C

```


C

CALCULATE FINAL STATISTICAL VALUES

```

TCUST=NCUST(I)
IF(ITYPE.EQ.2) TCUST=NCUST(1)+NCUST(2);
-PL=NCUST(1)/TCUST; NCUST(1)=TCUST
DO 55 J=1,KP(I)
  WAIT=TIME-TIM(J,I)
  DELAY(I)=DELAY(I)+WAIT
  IF(WAIT.GT.XMDELAY(I)) XMDELAY(I)=WAIT
  DELAYO(I)=DELAYO(I)+1
55 IF(WAIT.GT.XD) DELAYX(I)=DELAYX(I)+1
  SC(I)=CLTIME(I)/(TCUST-LINE(I))
  SV(I)=SORT(CLTIMSQ(I)/(TCUST-LINE(I))-SC(I)**2)
  K=1; M1=1
  IF(ITYPE.NE.5) M2=6; GO TO 59
  IF(I.EQ.1) M2=3; GO TO 59
  M1=4; M2=6; K=2
  DO 60 J=M1,M2
59 IF(ETIME(J).EQ.99999.) GO TO 60
  CLTIME(K)=CLTIME(K)-(ETIME(J)-TIME)
60 CONTINUE
  QT(I)=CUSTIM(I)/TIME
  BT(I)=CLTIME(I)/TIME
  LT(I)=QT(I)+BT(I)
  QC(I)=LT(I)/TCUST
  BC(I)=ISTOT(I)/TCUST
  LC(I)=QC(I)+BC(I)
  DC(I)=DELAY(I)/TCUST
  WC(I)=DC(I)+SC(I)
  DM(I)=XMDELAY(I)
  DO(I)=DELAYO(I)/TCUST
  DX(I)=DELAYX(I)/TCUST
  QM(I)=MAXLN(I)
  QO(I)=PROB(I)/TIME
  QL(I)=PROB(I)/TIME
  DV(I)=SORT(DELAYSQ(I)/TCUST-DC(I)**2)
  QV(I)=SORT(CLTIMSQ(I)/TIME-QT(I)**2)
  NC(I)=NCUST(I)
  IF(ITYPE.NE.2) PL=0.0
  IF(ITYPE.NE.5) GO TO 70
  IF(I.EQ.1) I=2; GO TO 50
  GO TO 80
70 QT(2)=BT(2)=LT(2)=QC(2)=BC(2)=LC(2)=DC(2)=SC(2)=
  -WC(2)=DV(2)=SV(2)=QV(2)=DM(2)=DO(2)=DX(2)=QM(2)=
  -QO(2)=QL(2)=NC(2)=0
80 RETURN
END

```


SUBROUTINE ARRIV

PURPOSE: RECORD AN ARRIVAL TO THE QUEUE IN THE HISTORY,
GATHER STATISTICS, AND DETERMINE IF A SERVER
IS AVAILABLE

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SUBROUTINE ARRIV
DIMENSION IBUFF(400)
DIMENSION NO(2)
DATA NO/1,2/
COMMON /SET6/ CLCCK(100),KIM(100),LOG(100)
COMMON /SET7/ FTIME(9),I,I3,K1,TIM(115,4)
COMMON /SET9/ IDIST(4),RATE(4),KK(4),CV(4),NFDBK,IFDBK,IDSPLN(2),
IDUAL,IBUSY(6),KP(2),LINE(2),TIME,PSTIME,PTIME,IX1,
IX2,IX3,IX4,XD,LQ,MAXQ,P
COMMON /SET10/ NTOT,ITYPE
COMMON /SET11/ NCUST(2),MAXLN(2),DELAY(2),DELAYSQ(2),XMDELAY(2),
DELAYO(2),DELAYX(2),CLTIME(2),CLTIMSQ(2),CUSTIM(2),CTIMSQ(2),
PROB0(2),PROBL(2),LTOT(2),ISTOT(2)
COMMON /EQUIVALENCE (IBUFF(1),CLOCK(1)),(IBUFF(201),KIM(1)),
(IBUFF(301),LOG(1))
KP(1)=KP(1)+1

```

```

CCCCC
      QUEUE AT CAPACITY? STOP
      IF(KP(1).GE.114) ETIME(9)=TIME-1.0; RETURN
CCCCC
      GATHER STATISTICS

```

```

50      LTOT(I)=LTOT(I)+LINE(I)
      IF(ITYPE.EQ.5) GO TO 51
      DO 50 J=1,6
      IF(IBUSY(J).EQ.2) GO TO 54
      ISTOT(I)=ISTOT(I)+IBUSY(J)
      GO TO 54
51      DO 52 J=1,3
      IF(IBUSY(J).EQ.2) GO TO 54
      ISTOT(I)=ISTOT(I)+IBUSY(J)
52      IF(IFDRK.EQ.1) GO TO 13
54      IF(ITYPE.NE.2) GO TO 5

```

CC
IN (11) PLANE 027, 003
DETERMINE IF LOST


```

C      IF(LINE(1).LT.MAXQ) GO TO 5
C
C      HISTORY ENTRY
C
C      CLOCK(I3)=TIME-PSTIME
C      KIM(I3)=NO(2)
C
C      ALTERNATE IMAGES
C
C      IF(NO(2).EQ.2) NO(2)=4: GO TO 101
C      NO(2)=2
C      LOG(I3)=2
C      I3=I3+1: NTOI=NTOI+1
C      IF(I3.NE.101) GO TO 4
C      CALL BUFFEROUT(7,1,IBUFF,400,IND)
C      IF(IND.EQ.1) GO TO 1
C      GO TO (1,3,2,2) IND
C      OUTPUT(101)'BUFFERING ERROR 1'
C      I3=1
C      NCUST(2)=NCUST(2)+1
C      PSTIME=TIME
C      KP(1)=KP(1)-1
C      GO TO 40
C      5 IF(ITYPE.GE.5 .OR. ITYPE.EQ.2) J=1: GO TO 6
C      IF(J.EQ.1) J=2: GO TO 6
C      J=1
C
C      ALTERNATE IMAGES
C
C      6 IF(NO(J).EQ.J) NO(J)=J+2: GO TO 8
C      NO(J)=J
C
C      HISTORY ENTRY
C
C      8 KIM(I3)=NO(J)
C      CLOCK(I3)=TIME-PSTIME
C      LOG(I3)=1
C      I3=I3+1: NTOI=NTOI+1
C      IF(I3.NE.101) GO TO 12
C      CALL BUFFEROUT(7,1,IBUFF,400,IND)
C      IF(IND.EQ.1) GO TO 9
C      GO TO (9,11,10,10) IND
C      OUTPUT(101)'BUFFERING ERROR 2'
C      I3=1
C
C      TIME STATISTICS
C

```



```

13 NCUST(I)=NCUST(I)+1
   LINE(I)=LINE(I)+1
   IF(IFDBK.EQ.1) IFDBK=0: GO TO 42
C
C
C
   SERVER AVAILABLE?
   IF(LINE(I).GT.1) GO TO 40
   LOG(I3)=7
   IF(ITYPE.LE.4) GO TO 30
   IF(I.EQ.2) GO TO 20
   DO 15 K1=1,3
15  IF(IBUSY(K1).EQ.0) CALL BEGSRV: GO TO 40
   GO TO 40
20  DO 21 K1=4,6
21  IF(IBUSY(K1).EQ.0) CALL BEGSRV: GO TO 40
   GO TO 40
30  DO 31 K1=1,6
31  IF(IBUSY(K1).EQ.0) CALL BEGSRV: GO TO 40
40  IF(ITYPE.NE.3) GO TO 45
C
C
C
   FINITE SOURCE EMPTY?
   IF(KP(2).EQ.0) ETIME(7)=99999.: GO TO 42
C
C
C
   SWITCH NEXT ARRIVAL TO QUEUE HALF OF ARRAY
   TIM(KP(1)+1,1)=TIM(KP(2),2)
   TIM(KP(1)+1,3)=TIM(KP(2),4)
   KP(2)=KP(2)-1
   GO TO 41
C
C
C
   GET NEXT ARRIVAL TIMES
45  CALL TIMES
41  ETIME(I+6)=TIM(KP(I)+1,I)
42  IF(LINE(I).GT.MAXLN(I)) MAXLN(I)=LINE(I)
   RETURN
   END

```


[illegible]

SUBROUTINE BEGSRV

PURPOSE: RECORD BEGINNING OF SERVICE:
AND SETS END OF SERVICE TIME

[illegible]

```

SUBROUTINE BEGSRV
DIMENSION IBUFF(400)
COMMON /SET6/ CLOCK(100), KIM(100), LOG(100)
COMMON /SET7/ ETIME(9), I, I3, K1, TIM(115,4)
COMMON /SET9/ IDIST(4), RATE(4), KK(4), CV(4), NFDBK, IFDBK, IDSPLN(2),
- IDUAL, IBUSY(6), KP(2), LINE(2), TIME, PTIME, PTIME(2), RUNTIME, IX1,
- IX2, IX3, IX4, XD, LQ, MAXQ, P
COMMON /SET10/ NTOT, I, TYPE
COMMON /SET11/ NCUST(2), MAXLN(2), DELAY(2), DELAYSQ(2), XMDELAY(2),
- DELAYO(2), DELAYX(2), CLTIME(2), CLTIMSQ(2), CUSTIM(2), CTIMSQ(2),
- PROBO(2), PROBL(2), LTOT(2), ISTOT(2)
COMMON EQUIVALENCE (IBUFF(1), CLOCK(1)), (IBUFF(201), KIM(1)),
- (IBUFF(301), LOG(1))

```

HISTORY ENTRY

CLOCK(I3)=TIME-PSTIME

```

1 KIM(I3)=K1+4
2 I3=I3+1: NIOI=NTOT+1
3 IF(I3.NE.IOI) GO TO 4
4 CALL BUFFEROUT(7,1,IBUFF,400,IND)
5 IF(IND.EQ.1) GO TO 1
6 GO TO (1,3,2), IND
7 OUTPUT(101),BUFFERING ERROR 4,
8 I3=1

```

SERVER BUSY

```
4 IBUSY(K1)=1
  II=I+2
```

SELECT QUEUE DISCIPLINE

GO TO (10,20,30,40) IDSPLN(I)

FIFO


```

10 STIME=TIM(1,II)
   WAIT=TIME-TIM(1,I)
   K=1
   GO TO 50
C
C
C
20 STIME=TIM(KP(I),II)
   WAIT=TIME-TIM(KP(I),I)
   K=KP(I)
   GO TO 50
C
C
C
SSTF
30 STIME=TIM(1,II)
   K=1
   DO 35 J=2,KP(I)
   IF(TIM(J,II).LT.STIME) STIME=TIM(J,II); K=J
   WAIT=TIME-TIM(K,I)
   GO TO 50
C
C
C
RANDOM
40 PIECE=1.0/KP(I)
   IX4=IX4+4099; RN=0.5+IX4*.5960464E-7
   K=1
   REPEAT 45 WHILE (K*PIECE).LT.RN
45 K=K+1
   STIME=TIM(K,II)
   WAIT=TIME-TIM(K,I)
C
C
C
ADJUST ARRAY
50 DO 55 J=K,KP(I)
   TIM(J,I)=TIM(J+1,I)
55 KP(I)=KP(I)-1
C
C
C
MINIMUM SERVICE TIME 1.2 SECONDS (TIME FOR MOTION)
STIME=AMAX(STIME,1.2)
C
C
C
STATISTICS
60 DELAY(I)=DELAY(I)+WAIT
   DELAYSQ(I)=DELAYSQ(I)+WAIT**2
   IF(WAIT.GT.XMDELAY(I)) XMDELAY(I)=WAIT
   IF(WAIT.GT.0.0) DELAYO(I)=DELAYO(I)+1
C
C
C

```



```

IF(WAIT.GT.XD) DELAYX(I)=DELAYX(I)+1
CLTIME(I)=CLTIME(I)+STIME
CLTIMSQ(I)=CLTIMSQ(I)+STIME**2
SET END-OF-SERVICE-TIME
ETIME(K1)=TIME+STIME
LINE(I)=LINE(I)-1
RETURN
END

```

```

C
C
C

```



```

CCCCCCCCCCCC
SUBROUTINE ENDSRV
PURPOSE:  RECORD END-OF-SERVICE IN HISTORY AND DETERMINE
          IF BEGIN SERVICE FOLLOWS
*****
SUBROUTINE ENDSRV
DIMENSION IBUFF(400)
DIMENSION NO(6)
DATA NO/6*0/
COMMON /SET6/ CLOCK(100),KIM(100),LOG(100)
COMMON /SET7/ ETIME(9),I,I3,K1,TIM(115,4)
COMMON /SET9/ IDIST(4),RATE(4),KK(4),CV(4),Nfdbk,IFDBK,IDSPLN(2),
- IDUAL,IBUSY(6),KP(2),LINE(2),TIME,PSTIME,PRTIME,IX1,
- IX2,IX3,IX4,XD,LQ,MAXQ,P
COMMON /SET10/ NTOT,ITYPE
COMMON /SET11/ NCUST(2),MAXLN(2),DELAY(2),DELAYSQ(2),XMDELAY(2),
- DELAYO(2),DELA YX(2),CLTIME(2),CLTIMSQ(2),CUSTIM(2),CTIMSQ(2),
- PROBO(2),PROBL(2),LTOT(2),ISTOT(2)
- EQUIVALENCE (IBUFF(1),CLOCK(1)),(IBUFF(201),KIM(1)),
- (IBUFF(301),LOG(1))
SERVER NOT BUSY
IBUSY(K1)=0
IF(ITYPE.NE.4) GO TO 10
DETERMINE IF FEEDBACK
IX3=IX3+4099; RN=0.5+IX3*.5960464E-7
IF(RN.GT.P) IFDBK=1; Nfdbk=Nfdbk+1
HISTORY ENTRY
10 CLOCK(I3)=TIME-PSTIME
ALTERNATE IMAGES
IF(NO(K1).EQ.0) NO(K1)=1; GO TO 100
NO(K1)=0
KIM(I3)=K1+10+6*NO(K1)
IF(IFDBK.EQ.1) LCG(I3)=2; GO TO 11
IF(ITYPE.EQ.3) LOG(I3)=2; GO TO 11
100
*****

```



```

LOG(I3)=1
11 I3=I3+1: NTOT=NTOT+1
   IF(I3.NE.101) GO TO 15
   CALL BUFFEROUT(7,1,IBUFF,400,IND)
12 IF(IND.EQ.1) GO TO 12
   GO TO (12,14,13,13) IND
13 OUTPUT(101) 'BUFFERING ERROR 3'
14 I3=1
      TIME STATISTICS
      C
      C
      C
15 CALL ACCUM
      IN CASE OF BEGIN-SERVICE
      C
      C
      C
      LOG(I3)=6
      IF(IFDBK.EQ.0) GO TO 17
      CAUSES DELAY
      C
      C
      C
      IF(LINE(1).EQ.0) LOG(I3)=7
      CALL TIMES: KP(1)=KP(1)+1: CALL BEGSRV: KP(1)=KP(1)-1:
      -CALL ARRIV: RETURN
      C
      C
      C
      QUEUE EMPTY?
      C
      C
      C
17 IF(LINE(1).EQ.0) ETIME(K1)=99999.: GO TO 20
   CALL BEGSRV
20 IF(ITYPE.NE.3) RETURN
      FEEDBACK SERVICE TIME
      C
      C
      C
      I=2: CALL TIMES
      IF(KP(2).NE.1) GO TO 19
      FEEDBACK TO EMPTY QUEUE?
      C
      C
      C
      TIM(KP(1)+1,1)=TIM(KP(2),2)
      TIM(KP(1)+1,3)=TIM(KP(2),4)
      KP(2)=KP(2)-1
      ETIME(7)=TIM(KP(1)+1,1)
19 RETURN
   END

```



```

C
C
C
C
C
C
C
C
SUBROUTINE ACCUM
PURPOSE:  GATHER TIME STATISTICS AND ADVANCE STATE CHANGE
VARIABLES

```

```

SUBROUTINE ACCUM
COMMON /SET7/ ETIME(9), I, I3, K1, TIM(115,4)
COMMON /SET9/ IDIST(4), RATE(4), KK(4), CV(4), NFDBK, IFDBK, IDSPLN(2),
- IX2, IX3, IX4, XD, LQ, MAXQ, P
COMMON /SET10/ NTOT, ITYPE
COMMON /SET11/ NCUST(2), MAXLN(2), DELAY(2), DELAYSQ(2), XMDELAY(2),
- DELAYO(2), DELAYX(2), CLTIME(2), CLTIMSQ(2), CUSTIM(2), CTIMSQ(2),
- PROBO(2), PROBL(2), LTOT(2), ISTOT(2)
Z=TIME-PTIME(I)
CUSTIM(I)=CUSTIM(I)+LINE(I)*Z
CTIMSQ(I)=CTIMSQ(I)+(LINE(I)*Z)**2
IF(LINE(I).GT.0) PROBO(I)=PROBO(I)+Z
IF(LINE(I).GT.LQ) PROBL(I)=PROBL(I)+Z
ADVANCE STATE CHANGE VARIABLES TO NOW
PTIME(I)=TIME
PSTIME=TIME
RETURN
END

```

```

C
C

```



```

CCCCCCCC
SUBROUTINE TIMES
PURPOSE: TO GENERATE AND STORE ARRIVAL (OR IDLE) TIMES
          AND SERVICE TIMES

SUBROUTINE TIMES
COMMON /SET7/ ETIME(9), I, I3, K1, TIM(115,4)
COMMON /SET9/ IDIST(4), RATE(4), KK(4), CV(4), NFDBK, IFDBK, IDSPLN(2),
- IDUAL, IBUSY(6), KP(2), LINE(2), TIME, PSTIME, PTIME(2), RUNTIME, IX1,
- IX2, IX3, IX4, XD, LQ, MAXQ, P
COMMON /SET10/ NTOT, ITYPE
COMMON /SET11/ NCUST(2), MAXLN(2), DELAY(2), DELAYSQ(2), XMDELAY(2),
- DELAYO(2), DELAYX(2), CLTIME(2), CLTIMSQ(2), CUSTIM(2), CTIMSQ(2),
- PROBO(2), PROBL(2), LTOT(2), ISTOT(2)

FIRST TIME THROUGH GETS ARRIVAL (OR IDLE) TIME
IDLE TIMES STORED IN COLUMN 2
I2=1
FEEDBACK? SLIP INTO QUEUE TIME ARRAY
IF( IFDBK.EQ.1) TIM(KP(1)+2, I2)=TIM(KP(1)+1, I2);
- TIM(KP(1)+2, I2+2)=TIM(KP(1)+1, I2+2);
- TIM(KP(1)+1, I2)=TIME; I2=I+2; GO TO 1
IF( ITYPE.NE.5) GO TO 1

DUAL ARRIVAL STREAMS?
IF( IDUAL.EQ.1.AND.I.EQ.2) TIM(KP(2)+1,2)=TIM(KP(1)+1,1); I2=I+2

SELECT DISTRIBUTION
1 GO TO (10,20,30) IDIST(I2)
K-ERLANG
10 U=1.0/(KK(I2)*RATE(I2))
SV=0.0
DO 11 J=1, KK(I2)
GENERATE RANDOM NUMBER BETWEEN 0 AND 1

```



```

C
11 IX1=IX1*4099; RN=0.5+IX1*.5960464E-7
   SV=SV-U*ALOG(RN)
   GO TO 88
C
C
C   HYPEREXPONENTIAL
20 IX1=IX1*4099; RN1=0.5+IX1*.5960464E-7
   IX2=IX2*4099; RN2=0.5+IX2*.5960464E-7
   U=1.0/RATE(I2)
   P=1.0/(CV(I2)**2)
   UX=0.2928932
   IF(P*GE*RN1) UX=(U-((1.0-P)*UX))/P
   SV=-UX*ALOG(RN2)
   GO TO 88
C
C
C   DEGENERATE
30 SV=1.0/RATE(I2)
88 IF(I2.NE.1) GO TO 89
C
C
C   MINIMUM INTER-ARRIVAL TIME=0.5 ( MOTION TIME)
-GO TO 87
IF(ITYPE.EQ.2 .OR. ITYPE.EQ.5) SV=AMAX(SV,0.5);
C
C
C   MINIMUM INTER-ARRIVAL TIME=0.3 ( MOTION TIME)
SV=AMAX(SV,0.3)
87 TIM(KP(I)+1,I2)=SV+TIME
   I2=I+2
   GO TO 1
89 TIM(KP(I)+1,I2)=SV
   IF(ITYPE.NE.3) GO TO 95
   IF(KP(2).EQ.0) GO TO 91
C
C
C   NEXT END-IDLE TIME AT TAIL OF ARRAY
TEMP1=TIM(KP(I)+1,2)
TEMP2=TIM(KP(I)+1,4)
J=KP(I)
REPEAT 90 WHILE TEMP1.GT.TIM(J,2) .AND. J.GT.0
   TIM(J+1,2)=TIM(J,2); TIM(J+1,4)=TIM(J,4)
   J=J+1
90 TIM(J+1,2)=TEMP1; TIM(J+1,4)=TEMP2
91 KP(2)=KP(2)+1
95 RETURN
   END

```


[illegible]

PURPOSE: DISPLAY THE STATISTICS PAGE

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52


```

ENCODE(44, 9, IWORD) DM(1), DM(2), QM(1), QM(2)
CALL TEXT0 (IDEV, IWORD, 11, 25, 7, 2, 3, IER)
ENCODE(44, 10, IWORD) DO(1), DO(2), QO(1), QO(2)
CALL TEXT0 (IDEV, IWORD, 11, 27, 7, 2, 3, IER)
ENCODE(44, 11, IWORD) DX(1), DX(2), QL(1), QL(2)
CALL TEXT0 (IDEV, IWORD, 11, 29, 7, 2, 3, IER)
ENCODE(44, 12, IWORD) NC(1), NC(2), PL
CALL TEXT0 (IDEV, IWORD, 11, 32, 7, 2, 3, IER)
ENCODE(44, 13, IWORD)
CALL TEXT0 (IDEV, IWORD, 11, 34, 7, 2, 3, IER)
ENCODE(44, 14, IWORD)
CALL TEXT0 (IDEV, IWORD, 11, 36, 7, 2, 3, IER)
RETURN
END

```


CCCCCCCC

SUBROUTINE PARAMETERS

PURPOSE: DISPLAY THE CURRENT PARAMETERS

```

SUBROUTINE PARAMETERS
DIMENSION IWORD(11)
COMMON /SET3/X(14), Y(25), MD(6), IC, IC1, NULL
COMMON /SET5/ IDEV, IER
COMMON /SET8/ CHNG(10), ENDD(5,22), IFLAG(22), ITOT, IPOP(2), XX(5,22),
-ILN(2), IMAN(7,22), NSIM, NQ(2), ITQ(2,2), NPOP, ITPOP(2), XX(5,22),
-XXX(5,22), YY(5,22), YYY(5,22), IMD(5)
COMMON /SET9/ IDIST(4), RATE(4), KK(4), CV(4), NFDBK, IFDBK, IDSPLN(2),
-IDUAL, IBUSY(6), KP(2), LINE(2), TIME, PTIME(2), RUNTIME, IX1,
-IX2, IX3, IX4, XD, LQ, MAXQ, P
COMMON /SET10/ NTOT, ITYPE
FORMAT(7X, 'ITYPE', 5X, I4, 6X, 'RUNTIME', F5.2, 3X)
FORMAT(7X, 'IC', 8X, I4, 6X, 'IC1', 7X, I4, 3X)
FORMAT(10X, 'I', 9X, '2', 9X, '3', 9X, '4', 3X)
FORMAT('KK', 14, 6X, I4, 6X, I4, 6X, I4, 3X)
FORMAT('RATE', 14, 6X, I4, 6X, I4, 6X, I4, 3X)
FORMAT('CV', F5.2, 5X, F5.2, 5X, F5.2, 5X, F5.2, 3X)
FORMAT('IDSPLN', 14, 6X, I4, 23X)
FORMAT(7X, 'LQ', 8X, I4, 6X, 'MAXQ', 6X, I4, 3X)
FORMAT(7X, 'XD', 7X, F5.2, 6X, 'NPOP', 5X, I4, 3X)
FORMAT(7X, 'IDUAL', 5X, I4, 6X, 'P', 8X, F5.2, 3X)
FORMAT(12X, 'ENTER 1. CONTINUE', 14X)
FORMAT(19X, '2. STATISTICS', 12X)
ENCODE(44, 1. IWORD) ITYPE, RUNTIME
CALL TEXT(1, IDEV, IWORD, 11, 8, 7, 2, 3, IER)
ENCODE(44, 2. IWORD) IC, IC1
CALL TEXT(1, IDEV, IWORD, 11, 10, 7, 2, 3, IER)
ENCODE(44, 3. IWORD)
CALL TEXT(1, IDEV, IWORD, 11, 13, 7, 2, 3, IER)
ENCODE(44, 4. IWORD) IDIST(1), IDIST(2), IDIST(3), IDIST(4)
CALL TEXT(1, IDEV, IWORD, 11, 15, 7, 2, 3, IER)
ENCODE(44, 5. IWORD) KK(1), KK(2), KK(3), KK(4)
CALL TEXT(1, IDEV, IWORD, 11, 17, 7, 2, 3, IER)
ENCODE(44, 6. IWORD) RATE(1), RATE(2), RATE(3), RATE(4)
CALL TEXT(1, IDEV, IWORD, 11, 19, 7, 2, 3, IER)
ENCODE(44, 7. IWORD) CV(1), CV(2), CV(3), CV(4)
CALL TEXT(1, IDEV, IWORD, 11, 21, 7, 2, 3, IER)

```



```

ENCODE (44, 8, IWORD) IDSPLN(1), IDSPLN(2)
CALL TEXT0 (IDEV, IWORD, 11, 23, 7, 2, 3, IER)
ENCODE (44, 9, IWORD) LQ, MAXQ
CALL TEXT0 (IDEV, IWORD, 11, 26, 7, 2, 3, IER)
ENCODE (44, 10, IWORD) XD, NPOP
CALL TEXT0 (IDEV, IWORD, 11, 28, 7, 2, 3, IER)
ENCODE (44, 11, IWORD) IDUAL, P
CALL TEXT0 (IDEV, IWORD, 11, 30, 7, 2, 3, IER)
ENCODE (44, 12, IWORD)
CALL TEXT0 (IDEV, IWORD, 11, 33, 7, 2, 3, IER)
ENCODE (44, 13, IWORD)
CALL TEXT0 (IDEV, IWORD, 11, 35, 7, 2, 3, IER)
RETURN
END

```


30 REWIND 7: RETURN
END

一、各級政府應注意其行政之改進，並加強其行政機構，以適應社會之需要。

SUBROUTINE SETFLAGS

PURPOSE: SET IMAGE FLAGS AS PER TIME HISTORY AT THE OCCURRENCE OF A TIMING INTERRUPT (533 INTERRUPT)

卷之六 詩集 七言律詩 七

```

SUBROUTINE SET FLAGS
COMMON /SET6/  CLOCK(100), KIM(100), LOG(100)
COMMON /SET8/  CHNG(10), ENDD(5,22), IELAG(22), ITOT, IPOS(2),
--ILN(2), IMAN(7,22), NSIM,NQ(2), ITQ(2,2), NPOP, ITPOP(2), XX(5,22),
--XXX(5,22), YY(5,22), YYY(5,22), IMD(5)
COMMON /SET10/ NTOT, ITYPE
COMMON /SET12/ IDONE, I3, IM

```

SET CORRECT IMAGE FLAG TO MOVEMENT LOGIC VALUE AS PER HISTORY

```
10 IFLAG(KIM(I3))=LOG(I3)
```

```

I3=I3+1
ITOT=ITOT+1
IF(ITOT.GT.NTOT) IDONE=3: RETURN
IF(I3.GT.100) IDONE=2: RETURN

```

IF TIME TO NEXT EVENT IS SMALL, SET THE FLAG

```
IF(CLOCK(I3).LE.0.1) GO TO 10
```

SET MAX (HYBRID LIMITATION)

IF(CLOCK(I3).GT.99.) CLOCK(I3)=99.

SET THE TIMER FOR THE NEXT EVENT INTERRUPT

```
CALL DAC(1,CLOCK(I3)/100.)
CALL COMPUTE
RETURN
END
```



```

6 NQ(IT)=NQ(IT)+1;
  -IF(NQ(IT).GT.0) ENCODE(4,1,ITQ(1,IT)) NQ(IT);
  -CALL TEXTQ (IDEV,ITQ(1,IT),2,ILN(IT),IPOS(IT),3,3,IER)
13 CALL REMAN: GO TO 99
18 DO 19 I=2,6
  J=I-1
  XX(J,IM)=XX(J,IM)+CHNG(1)
19 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
  GO TO 99
C
C
C HORIZONTAL MOVEMENT RIGHT (WHEN A COURSE CHANGE WILL OCCUR)
20 IF(XX(1,IM).NE.XXX(1,IM).OR.IM.LE.10) GO TO 7
  IF(IM.GE.17) IM=IM-12; CALL REMAN: IM=IM+12; GO TO 7
  IM=IM-6; CALL REMAN: IM=IM+6
7 CALL GRAPHO (IDEV,IMAN(1,IM),7,NSIM+IM,IER)
  TEST=XX(1,IM)+CHNG(3)
  IF(TEST.GT.ENDD(1,IM)) IFLAG(IM)=3; GO TO 99
  DO 28 I=2,6
    J=I-1
    XX(J,IM)=XX(J,IM)+CHNG(3)
28 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
    GO TO 99
C
C
C VERTICAL MOVEMENT DOWNWARD
30 CALL GRAPHO (IDEV,IMAN(1,IM),7,NSIM+IM,IER)
  TEST=YY(1,IM)-CHNG(3)
  IF(TEST.GE.ENDD(2,IM)) GO TO 31
  IF(IM.LE.4) CALL REMAN: GO TO 99
  IFLAG(IM)=4; GO TO 99
31 DO 38 I=2,6
  J=I-1
  YY(J,IM)=YY(J,IM)-CHNG(3)
38 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
  GO TO 99
C
C
C HORIZONTAL MOVEMENT TO THE LEFT
40 CALL GRAPHO (IDEV,IMAN(1,IM),7,NSIM+IM,IER)
  TEST=XX(1,IM)-CHNG(3)*2.0
  IF(TEST.GE.ENDD(3,IM)) GO TO 47
45 IFLAG(IM)=5; GO TO 99
47 DO 48 I=2,6
  J=I-1
  XX(J,IM)=XX(J,IM)-CHNG(3)*2.0
48 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
  GO TO 99

```



```

C
C
C
      VERTICAL MOVEMENT UPWARD
50 CALL GRAPHO (IDEV,IMAN(1,IM),7,NSIM+IM,IER)
   TEST=YY(1,IM)+CHNG(4)
   IF(TEST.LE.ENDD(4,IM)) GO TO 57
   IF(ITYPE.NE.4) GO TO 55
   NQ(1)=NQ(1)+1
   IF(NQ(1).LE.0) GO TO 56
   FNCODE(4,1,ITQ(1,1)) NQ(1)
   CALL TEXTTO (IDEV,ITQ(1,1),2,ILN(1),IPOS(1),3,3,IER)
   GO TO 56
55 NPOP=NPOP+1; ENCODE(4,1,ITPOP) NPOP;
   -CALL TEXTTO (IDEV,ITPOP,2,ILN(2),IPOS(2),3,3,IER)
56 CALL REMAN: GO TO 99
57 DO 58 I=2,6
   J=I-1
   YY(J,IM)=YY(J,IM)+CHNG(4)
58 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
   GO TO 99

C
C
C
      MOVEMENT TO-SERVICE
60 IF(XX(1,IM).NE.XXX(1,IM)) GO TO 61
   IF(ITYPE.NE.5.OR. IM.LT.8) GO TO 65
   NQ(2)=NQ(2)-1
   IF(NQ(2).GE.0) ENCODE(4,1,ITQ(1,2)) NQ(2);
   -CALL TEXTTO (IDEV,ITQ(1,2),2,ILN(2),IPOS(2),3,3,IER)
   GO TO 61
65 NQ(1)=NQ(1)-1
   IF(NQ(1).LT.0) GO TO 61
   FNCODE(4,1,ITQ(1,1)) NQ(1)
   CALL TEXTTO (IDEV,ITQ(1,1),2,ILN(1),IPOS(1),3,3,IER)
61 CALL GRAPHO (IDEV,IMAN(1,IM),7,NSIM+IM,IER)
   TEST=XX(1,IM)+CHNG(2)
   IF(TEST.GT.ENDD(1,IM)) IFLAG(IM)=0; GO TO 99
   DO 68 I=2,6
   J=I-1
   XX(J,IM)=XX(J,IM)+CHNG(2)
   YY(J,IM)=YY(J,IM)+CHNG(IM)
68 IMAN(I,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
   GO TO 99

C
C
C
      CAUSE DELAY
70 IFLAG(IM)=8 : GO TO 99
71 IFLAG(IM)=9 : GO TO 99
72 IFLAG(IM)=10: GO TO 99

```



```
73 IFLAG(IM)=11: GO TO 99
74 IFLAG(IM)=12: GO TO 99
75 IFLAG(IM)=6 : GO TO 99
    END
```



```

CCCCCCCC
SUBROUTINE REMAN
PURPOSE:  BLANK OUT IMAGES, AND REPOSITION
CCCCCCCC

```

```

SUBROUTINE REMAN
COMMON /SET5/ IDEV, IER
COMMON /SET8/ CHNG(10), ENDD(5,22), IFLAG(22), ITOT, IPOS(2),
-ILN(2), IMAN(7,22), NSIM,NQ(2), ITQ(2,2), NPOP, ITPOP(2), XX(5,22),
-XXX(5,22), YY(5,22), YYY(5,22), IMD(5)
COMMON /SET10/ NTOT, ITYPE
COMMON /SET12/ IDONE, I3, IM
IF (IM.LE.4 .OR. IM.GE.11) IFLAG(IM)=0
DO 10 K=2,6
10  IMAN(K,IM)=0
CALL GRAPHQ (IDEV, IMAN(1,IM),7, NSIM+IM, IER)
DO 20 K=2,6
J=K-1
XX(J,IM)=XXX(J,IM)
YY(J,IM)=YYY(J,IM)
20  IMAN(K,IM)=IPACK(XX(J,IM),YY(J,IM),IMD(J))
RETURN
END

```



```

CCCCCCCC
SUBROUTINE GGC
PURPOSE: DISPLAY STATIC PICTURE FOR G/G/C MODEL

```

```

SUBROUTINE GGC
COMMON /SET1/ I SERV1(37), IPATH1(19), IPATH2(19), IPATH3(19),
- IPATH7(8)
COMMON /SET2/ I SERV2(19), IQUE1(7), IQUE2(12), IQUE3(7), IPATH4(10),
- IPATH5(10), IPATH9(7), IPATH10(5), IPATH11(4),
- IPATH12(4), IPATH13(6)
COMMON /SET3/ X(14), Y(25), MD(6), IC, IC1, NULL
COMMON /SET5/ IDEV, IER
DO 10 I=1, IC
10 MD(I)=1
CALL SERV1
CALL GRAPHO (IDEV, I SERV1, 6, IC+1, 1, IER)
CALL PATH1
CALL GRAPHO(IDEV, IPATH1, 3, IC+1, 2, IER)
CALL PATH2
CALL GRAPHO (IDEV, IPATH2, 3, IC+1, 3, IER)
CALL GRAPHO (IDEV, IPATH12, 4, 4, IER)
CALL GRAPHO (IDEV, IQUE1, 7, 5, IER)
RETURN
END

```



```

C
C
C
C
C
C
C
SUBROUTINE FEEDBACK
PURPOSE:  DISPLAY STATIC PICTURE FOR G/G/C WITH FEEDBACK

```

```

C
SUBROUTINE FEEDBK
COMMON /SET1/ISERV1(37),IPATH1(19),IPATH2(19),IPATH3(19),
-IPATH7(8)
COMMON /SET2/ISERV2(19),IQUE1(7),IQUE2(12),IQUE3(7),IPATH4(10),
-IPATH5(10),IPATH9(7),IPATH10(5),IPATH11(4),
-IPATH12(4),IPATH13(6)
COMMON /SET3/X(14),Y(25),MD(6),IC,IC1,NULL
COMMON /SET5/ IDEV, IER
CALL GGC
DO 10 I=1,4
10 MD(I)=1
IF(IC.LT.6)MD(1)=0;IF(IC.LT.4)MD(2)=0;IF(IC.LT.2)MD(3)=0
CALL PATH7
CALL GRAPHO (IDEV,IPATH7,8,6,IER)
CALL GRAPHO (IDEV,IPATH10,5,7,IER)
RETURN
END

```



```

CCCCCCCC
SUBROUTINE FINITE
PURPOSE: DISPLAY STATIC PICTURE FOR G/G/C WITH FINITE SOURCE

```

```

SUBROUTINE FINITE
COMMON /SET1/ISERV1(37),IPATH1(19),IPATH2(19),IPATH3(19),
-IPATH7(8)
COMMON /SET2/ISERV2(19),IQUE1(7),IQUE2(12),IQUE3(7),IPATH4(10),
-IPATH5(10),IPATH9(7),IPATH10(5),IPATH11(4),
-IPATH12(4),IPATH13(6)
COMMON /SET3/X(14),Y(25),MD(6),IC,IC1,NULL
COMMON /SET5/ IDEV,IER
DO 10 I=1,4
10 MD(I)=1
IF(IC.LT.6)MD(1)=0;IF(IC.LT.4)MD(2)=0;IF(IC.LT.2)MD(3)=0
CALL PATH7
DO 11 I=1,IC
11 MD(I)=1
CALL SERV1
CALL PATH1
CALL PATH3
CALL GRAPH0 (IDEV, ISERV1,6, IC+1,1,IER)
CALL GRAPH0 (IDEV, IQUE1,7,2,IER)
CALL GRAPH0 (IDEV, IQUE3,7,3,IER)
CALL GRAPH0 (IDEV, IPATH1,3, IC+1,4,IER)
CALL GRAPH0 (IDEV, IPATH3,3, IC+1,5,IER)
CALL GRAPH0 (IDEV, IPATH7,8,6,IER)
CALL GRAPH0 (IDEV, IPATH9,7,7,IER)
RETURN
END

```


CCCCCCCC

SUBROUTINE SERV1

PURPOSE: PACK THE SERVICE BOXES

CCCCCCCC

```
SUBROUTINE SERV1
COMMON /SET1/ISERV1(37),IPATH1(19),IPATH2(19),IPATH3(19),
-IPATH7(8)
COMMON /SET3/X(14),Y(25),MD(6),IC,IC1,NULL
ISERV1(1)=IHEAD(0,10)
ISERV1(2)=IPACK(X(11),Y(13),0)
ISERV1(3)=IPACK(X(11),Y(17),MD(1))
ISERV1(4)=IPACK(X(12),Y(17),MD(1))
ISERV1(5)=IPACK(X(12),Y(13),MD(1))
ISERV1(6)=IPACK(X(11),Y(13),MD(1))
ISERV1(7)=0
ISERV1(8)=IPACK(X(11),Y(11),0)
ISERV1(9)=IPACK(X(11),Y(7),MD(2))
ISERV1(10)=IPACK(X(12),Y(7),MD(2))
ISERV1(11)=IPACK(X(12),Y(11),MD(2))
ISERV1(12)=IPACK(X(11),Y(11),MD(2))
ISERV1(13)=0
ISERV1(14)=IPACK(X(11),Y(18),0)
ISERV1(15)=IPACK(X(11),Y(20),MD(3))
ISERV1(16)=IPACK(X(12),Y(20),MD(3))
ISERV1(17)=IPACK(X(12),Y(18),MD(3))
ISERV1(18)=IPACK(X(11),Y(18),MD(3))
ISERV1(19)=0
ISERV1(20)=IPACK(X(11),Y(6),0)
ISERV1(21)=IPACK(X(11),Y(4),MD(4))
ISERV1(22)=IPACK(X(12),Y(4),MD(4))
ISERV1(23)=IPACK(X(12),Y(6),MD(4))
ISERV1(24)=IPACK(X(11),Y(6),MD(4))
ISERV1(25)=0
ISERV1(26)=IPACK(X(11),Y(21),0)
ISERV1(27)=IPACK(X(11),Y(23),MD(5))
ISERV1(28)=IPACK(X(12),Y(23),MD(5))
ISERV1(29)=IPACK(X(12),Y(21),MD(5))
ISERV1(30)=IPACK(X(11),Y(21),MD(5))
ISERV1(31)=0
ISERV1(32)=IPACK(X(11),Y(3),0)
ISERV1(33)=IPACK(X(11),Y(1),MD(6))
ISERV1(34)=IPACK(X(12),Y(1),MD(6))
```



```
ISERV1(35)=IPACK(X(12),Y(3),MD(6))  
ISERV1(36)=IPACK(X(11),Y(3),MD(6))  
ISERV1(37)=0  
RETURN  
END
```


CCCCCCCC

SUBROUTINE PATH1

PURPOSE: PACK THE TO-SERVICE PATHS

```
SUBROUTINE PATH1
COMMON /SET1/ISERV1(37),IPATH1(19),IPATH2(19),IPATH3(19),
-IPATH7(8)
COMMON /SET3/X(14),Y(25),MD(6),IC,IC1,NULL
IPATH1(1)=IHEAD(1,8)
IPATH1(2)=IPACK(X(10),Y(12),0)
IPATH1(3)=IPACK(X(11),Y(15),MD(1))
IPATH1(4)=0
IPATH1(5)=IPACK(X(10),Y(12),0)
IPATH1(6)=IPACK(X(11),Y(9),MD(2))
IPATH1(7)=0
IPATH1(8)=IPACK(X(10),Y(12),0)
IPATH1(9)=IPACK(X(11),Y(19),MD(3))
IPATH1(10)=0
IPATH1(11)=IPACK(X(10),Y(12),0)
IPATH1(12)=IPACK(X(11),Y(5),MD(4))
IPATH1(13)=0
IPATH1(14)=IPACK(X(10),Y(12),0)
IPATH1(15)=IPACK(X(11),Y(22),MD(5))
IPATH1(16)=0
IPATH1(17)=IPACK(X(10),Y(12),0)
IPATH1(18)=IPACK(X(11),Y(2),MD(6))
IPATH1(19)=0
RETURN
END
```


CCCCCCCC

SUBROUTINE PATH2

PURPOSE: PACK THE HCRIZONTAL FROM-SERVICE PATHS

```

SUBROUTINE PATH2
COMMON /SET1/ISERV1(37), IPATH1(19), IPATH2(19), IPATH3(19),
-IPATH7(8)
COMMON /SET3/X(14), Y(25), MD(6), IC, IC1, NULL
IPATH2(1)=IHEAD(1,8)
IPATH2(2)=IPACK(X(12), Y(15), 0)
IPATH2(3)=IPACK(X(14), Y(15), MD(1))
IPATH2(4)=0
IPATH2(5)=IPACK(X(14), Y(9), 0)
IPATH2(6)=IPACK(X(12), Y(9), MD(2))
IPATH2(7)=0
IPATH2(8)=IPACK(X(12), Y(19), 0)
IPATH2(9)=IPACK(X(14), Y(19), MD(3))
IPATH2(10)=0
IPATH2(11)=IPACK(X(14), Y(5), 0)
IPATH2(12)=IPACK(X(12), Y(5), MD(4))
IPATH2(13)=0
IPATH2(14)=IPACK(X(12), Y(22), 0)
IPATH2(15)=IPACK(X(14), Y(22), MD(5))
IPATH2(16)=0
IPATH2(17)=IPACK(X(14), Y(2), 0)
IPATH2(18)=IPACK(X(12), Y(2), MD(6))
IPATH2(19)=0
RETURN
END

```



```

C
C
C
C
C
C
C
SUBROUTINE PATH3
PURPOSE:  PACK THE SHORT HORIZONTAL FROM-SERVICE PATHS

```

```

SUBROUTINE PATH3
COMMON /SET1/ISERV1(37), IPATH1(19), IPATH2(19), IPATH3(19),
-IPATH7(8)
COMMON /SET3/X(14), Y(25), MD(6), IC, ICI, NULL
IPATH3(1)=IHEAD(1,8)
IPATH3(2)=IPACK(X(12), Y(15), 0)
IPATH3(3)=IPACK(X(13), Y(15), MD(1))
IPATH3(4)=0
IPATH3(5)=IPACK(X(13), Y(9), 0)
IPATH3(6)=IPACK(X(12), Y(9), MD(2))
IPATH3(7)=0
IPATH3(8)=IPACK(X(12), Y(19), 0)
IPATH3(9)=IPACK(X(13), Y(19), MD(3))
IPATH3(10)=0
IPATH3(11)=IPACK(X(13), Y(5), 0)
IPATH3(12)=IPACK(X(12), Y(5), MD(4))
IPATH3(13)=0
IPATH3(14)=IPACK(X(12), Y(22), 0)
IPATH3(15)=IPACK(X(13), Y(22), MD(5))
IPATH3(16)=0
IPATH3(17)=IPACK(X(13), Y(2), 0)
IPATH3(18)=IPACK(X(12), Y(2), MD(6))
IPATH3(19)=0
RETURN
END

```


CCCCCCCC

SUBROUTINE PATH7

PURPOSE: PACK A VERTICAL PATH

```
SUBROUTINE PATH7
COMMON /SET1/ISERV1(37),IPATH1(19),IPATH2(19),IPATH3(19),
-IPATH7(8)
COMMON /SET3/X(14),Y(25),MD(6),IC,ICI, NULL
IPATH7(1)=IHEAD(1,8)
IPATH7(2)=IPACK(X(13),Y(2),0)
IPATH7(3)=IPACK(X(13),Y(5),MD(1))
IPATH7(4)=IPACK(X(13),Y(9),MD(2))
IPATH7(5)=IPACK(X(13),Y(15),MD(3))
IPATH7(6)=IPACK(X(13),Y(19),1)
IPATH7(7)=IPACK(X(13),Y(24),MD(4))
IPATH7(8)=0
RETURN
END
```


[illegible]

PURPOSE: PACK OTHER BOXES AND PATHS

此後我輩無不為世所共知也

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```

ISERV2(6)=IPACK(X(6),Y(18),1)
ISERV2(7)=0
ISERV2(8)=IPACK(X(6),Y(17),0)
ISERV2(9)=IPACK(X(6),Y(13),1)
ISERV2(10)=IPACK(X(4),Y(13),1)
ISERV2(11)=IPACK(X(4),Y(17),1)
ISERV2(12)=IPACK(X(6),Y(17),1)
ISERV2(13)=0
ISERV2(14)=IPACK(X(6),Y(21),0)
ISERV2(15)=IPACK(X(6),Y(23),1)
ISERV2(16)=IPACK(X(4),Y(23),1)
ISERV2(17)=IPACK(X(4),Y(21),1)
ISERV2(18)=IPACK(X(6),Y(21),1)
ISERV2(19)=0
IPATH4(1)=IHEAD(1,8)
IPATH4(2)=IPACK(X(10),Y(5),0)
IPATH4(3)=IPACK(X(11),Y(5),1)
IPATH4(4)=0
IPATH4(5)=IPACK(X(10),Y(5),0)
IPATH4(6)=IPACK(X(11),Y(9),1)
IPATH4(7)=0
IPATH4(8)=IPACK(X(10),Y(5),0)
IPATH4(9)=IPACK(X(11),Y(2),1)
IPATH4(10)=0
IPATH5(1)=IHEAD(1,8)
IPATH5(2)=IPACK(X(10),Y(19),0)
IPATH5(3)=IPACK(X(11),Y(19),1)
IPATH5(4)=0
IPATH5(5)=IPACK(X(10),Y(19),0)
IPATH5(6)=IPACK(X(11),Y(22),1)
IPATH5(7)=0
IPATH5(8)=IPACK(X(10),Y(19),0)
IPATH5(9)=IPACK(X(11),Y(15),1)
IPATH5(10)=0
IPATH9(1)=IHEAD(1,8)
IPATH9(2)=IPACK(X(13),Y(24),0)
IPATH9(3)=IPACK(X(5),Y(24),1)
IPATH9(4)=IPACK(X(5),Y(16),1)
IPATH9(5)=IPACK(X(7),Y(12),0)
IPATH9(6)=IPACK(X(9),Y(12),1)
IPATH9(7)=0
IPATH10(1)=IHEAD(1,8)
IPATH10(2)=IPACK(X(13),Y(24),0)
IPATH10(3)=IPACK(X(8),Y(24),1)
IPATH10(4)=IPACK(X(8),Y(12),1)
IPATH10(5)=0
IPATH11(1)=IHEAD(1,8)
IPATH11(2)=IPACK(X(8),Y(12),0)

```



```
IPATH11(3)=IPACK(X(8),Y(25),1)
IPATH11(4)=0
IPATH12(1)=IHEAD(1,8)
IPATH12(2)=IPACK(X(9),Y(12),0)
IPATH12(3)=IPACK(X(1),Y(12),1)
IPATH12(4)=0
IPATH13(1)=IHEAD(1,8)
IPATH13(2)=IPACK(X(9),Y(5),0)
IPATH13(3)=IPACK(X(1),Y(5),1)
IPATH13(4)=IPACK(X(1),Y(19),0)
IPATH13(5)=IPACK(X(9),Y(19),1)
IPATH13(6)=0
RETURN
END
```

SUBROUTINE XES

PURPOSE: POSITION ALL DYNAMIC IMAGES

```

SUBROUTINE XES
COMMON /SET3/X(14),Y(25),MD(6),IC,IC1,NULL
COMMON /SET5/ IDEV, IER
COMMON /SET8/ CHNG(10), ENDD(5,22), IFLAG(22), ITOT, IPOS(2),
-ILN(2), IMAN(7,22), NSIM, NQ(2), ITQ(2,2), NPOP, ITPOP(2), XX(5,22),
-XXX(5,22), YY(5,22), YYY(5,22), IMD(5)
COMMON /SETX/ A1,A2,A3,A4,G1,G2,G3,G4,S1,S2,S3,S4,S5,S6,S7,S8
DO 10 I=1,22
  IMAN(1,I)=IFHEAD(0,10)
  DO 9 J=2,7
    9 IMAN(J,I)=0
  10 CALL GRAPHO (IDEV, IMAN(1,I),7, NSIM+I, IER)
    XXX(1,01)=XX(1,01)=X(A1)+.02
    YYY(1,01)=YY(1,01)=Y(A3)-.05
    XXX(2,01)=XX(2,01)=X(A1)-.015
    YYY(2,01)=YY(2,01)=Y(A3)+.02
    XXX(3,01)=XX(3,01)=X(A1)
    YYY(3,01)=YY(3,01)=Y(A3)+.05
    XXX(4,01)=XX(4,01)=X(A1)+.015
    YYY(4,01)=YY(4,01)=Y(A3)+.02
    XXX(5,01)=XX(5,01)=X(A1)-.02
    YYY(5,01)=YY(5,01)=Y(A3)-.05
    XXX(1,02)=XX(1,02)=X(A2)+.02
    YYY(1,02)=YY(1,02)=Y(A4)-.05
    XXX(2,02)=XX(2,02)=X(A2)-.015
    YYY(2,02)=YY(2,02)=Y(A4)+.02
    XXX(3,02)=XX(3,02)=X(A2)
    YYY(3,02)=YY(3,02)=Y(A4)+.05
    XXX(4,02)=XX(4,02)=X(A2)+.015
    YYY(4,02)=YY(4,02)=Y(A4)+.02
    XXX(5,02)=XX(5,02)=X(A2)-.02
    YYY(5,02)=YY(5,02)=Y(A4)-.05
    XXX(1,03)=XX(1,03)=X(A1)+.02
    YYY(1,03)=YY(1,03)=Y(A3)-.05
    XXX(2,03)=XX(2,03)=X(A1)-.015
    YYY(2,03)=YY(2,03)=Y(A3)+.02
    XXX(3,03)=XX(3,03)=X(A1)

```

C
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YY(3,03)=YY(3,03)=Y(A3)+.05
 XX(4,03)=XX(4,03)=X(A1)+.015
 YY(4,03)=YY(4,03)=Y(A3)+.02
 XX(5,03)=XX(5,03)=X(A1)-.02
 YY(5,03)=YY(5,03)=Y(A3)-.05
 XX(1,04)=XX(1,04)=X(A2)+.02
 YY(1,04)=YY(1,04)=Y(A4)-.05
 XX(2,04)=XX(2,04)=X(A2)-.015
 YY(2,04)=YY(2,04)=Y(A4)+.02
 XX(3,04)=XX(3,04)=X(A2)
 YY(3,04)=YY(3,04)=Y(A4)+.05
 XX(4,04)=XX(4,04)=X(A2)+.015
 YY(4,04)=YY(4,04)=Y(A4)+.02
 XX(5,04)=XX(5,04)=X(A2)-.02
 YY(5,04)=YY(5,04)=Y(A4)-.05
 XX(1,05)=XX(1,05)=X(G1)+.02
 YY(1,05)=YY(1,05)=Y(G3)-.05
 XX(2,05)=XX(2,05)=X(G1)-.015
 YY(2,05)=YY(2,05)=Y(G3)+.02
 XX(3,05)=XX(3,05)=X(G1)
 YY(3,05)=YY(3,05)=Y(G3)+.05
 XX(4,05)=XX(4,05)=X(G1)+.015
 YY(4,05)=YY(4,05)=Y(G3)+.02
 XX(5,05)=XX(5,05)=X(G1)-.02
 YY(5,05)=YY(5,05)=Y(G3)-.05
 XX(1,06)=XX(1,06)=X(G1)+.02
 YY(1,06)=YY(1,06)=Y(G3)-.05
 XX(2,06)=XX(2,06)=X(G1)-.015
 YY(2,06)=YY(2,06)=Y(G3)+.02
 XX(3,06)=XX(3,06)=X(G1)
 YY(3,06)=YY(3,06)=Y(G3)+.05
 XX(4,06)=XX(4,06)=X(G1)+.015
 YY(4,06)=YY(4,06)=Y(G3)+.02
 XX(5,06)=XX(5,06)=X(G1)-.02
 YY(5,06)=YY(5,06)=Y(G3)-.05
 XX(1,07)=XX(1,07)=X(G1)+.02
 YY(1,07)=YY(1,07)=Y(G3)-.05
 XX(2,07)=XX(2,07)=X(G1)-.015
 YY(2,07)=YY(2,07)=Y(G3)+.02
 XX(3,07)=XX(3,07)=X(G1)
 YY(3,07)=YY(3,07)=Y(G3)+.05
 XX(4,07)=XX(4,07)=X(G1)+.015
 YY(4,07)=YY(4,07)=Y(G3)+.02
 XX(5,07)=XX(5,07)=X(G1)-.02
 YY(5,07)=YY(5,07)=Y(G3)-.05
 XX(1,08)=XX(1,08)=X(G2)+.02
 YY(1,08)=YY(1,08)=Y(G4)-.05
 XX(2,08)=XX(2,08)=X(G2)-.015

YY(2,08)=YY(2,08)=Y(G4)+.02
 XX(3,08)=XX(3,08)=X(G2)
 YY(3,08)=YY(3,08)=Y(G4)+.05
 XX(4,08)=XX(4,08)=X(G4)+.015
 YY(4,08)=YY(4,08)=Y(G4)+.02
 XX(5,08)=XX(5,08)=X(G2)-.02
 YY(5,08)=YY(5,08)=Y(G4)-.05
 XX(1,09)=XX(1,09)=X(G2)+.02
 YY(1,09)=YY(1,09)=Y(G4)-.05
 XX(2,09)=XX(2,09)=X(G2)-.015
 YY(2,09)=YY(2,09)=Y(G4)+.02
 XX(3,09)=XX(3,09)=X(G2)+.05
 YY(3,09)=YY(3,09)=Y(G4)+.015
 XX(4,09)=XX(4,09)=X(G2)+.02
 YY(4,09)=YY(4,09)=Y(G4)+.02
 XX(5,09)=XX(5,09)=X(G2)-.02
 YY(5,09)=YY(5,09)=Y(G4)-.05
 XX(1,10)=XX(1,10)=X(G2)+.02
 YY(1,10)=YY(1,10)=Y(G4)-.05
 XX(2,10)=XX(2,10)=X(G2)-.015
 YY(2,10)=YY(2,10)=Y(G4)+.02
 XX(3,10)=XX(3,10)=X(G2)+.05
 YY(3,10)=YY(3,10)=Y(G4)+.015
 XX(4,10)=XX(4,10)=X(G2)+.02
 YY(4,10)=YY(4,10)=Y(G4)+.02
 XX(5,10)=XX(5,10)=X(G2)-.02
 YY(5,10)=YY(5,10)=Y(G4)-.05
 XX(1,11)=XX(1,11)=X(S1)+.02
 YY(1,11)=YY(1,11)=Y(S3)-.05
 XX(2,11)=XX(2,11)=X(S1)-.015
 YY(2,11)=YY(2,11)=Y(S3)+.02
 XX(3,11)=XX(3,11)=X(S1)+.05
 YY(3,11)=YY(3,11)=Y(S3)+.015
 XX(4,11)=XX(4,11)=X(S1)+.02
 YY(4,11)=YY(4,11)=Y(S3)+.02
 XX(5,11)=XX(5,11)=X(S1)-.02
 YY(5,11)=YY(5,11)=Y(S3)-.05
 XX(1,12)=XX(1,12)=X(S1)+.02
 YY(1,12)=YY(1,12)=Y(S4)-.05
 XX(2,12)=XX(2,12)=X(S1)-.015
 YY(2,12)=YY(2,12)=Y(S4)+.02
 XX(3,12)=XX(3,12)=X(S1)+.05
 YY(3,12)=YY(3,12)=Y(S4)+.015
 XX(4,12)=XX(4,12)=X(S1)+.02
 YY(4,12)=YY(4,12)=Y(S4)+.02
 XX(5,12)=XX(5,12)=X(S1)-.02
 YY(5,12)=YY(5,12)=Y(S4)-.05
 XX(1,13)=XX(1,13)=X(S1)+.02

YY(1,13)=YY(1,13)=Y(S5)-.05
 XX(2,13)=XX(2,13)=X(S1)-.015
 YY(2,13)=YY(2,13)=Y(S5)+.02
 XX(3,13)=XX(3,13)=X(S1)
 YY(3,13)=YY(3,13)=Y(S5)+.05
 XX(4,13)=XX(4,13)=X(S1)+.015
 YY(4,13)=YY(4,13)=Y(S5)+.02
 XX(5,13)=XX(5,13)=X(S1)-.02
 YY(5,13)=YY(5,13)=Y(S5)-.05
 XX(1,14)=XX(1,14)=X(S2)+.02
 YY(1,14)=YY(1,14)=Y(S6)-.05
 XX(2,14)=XX(2,14)=X(S2)-.015
 YY(2,14)=YY(2,14)=Y(S6)+.02
 XX(3,14)=XX(3,14)=X(S2)
 YY(3,14)=YY(3,14)=Y(S6)+.05
 XX(4,14)=XX(4,14)=X(S2)+.015
 YY(4,14)=YY(4,14)=Y(S6)+.02
 XX(5,14)=XX(5,14)=X(S2)-.02
 YY(5,14)=YY(5,14)=Y(S6)-.05
 XX(1,15)=XX(1,15)=X(S2)+.02
 YY(1,15)=YY(1,15)=Y(S7)-.05
 XX(2,15)=XX(2,15)=X(S2)-.015
 YY(2,15)=YY(2,15)=Y(S7)+.02
 XX(3,15)=XX(3,15)=X(S2)
 YY(3,15)=YY(3,15)=Y(S7)+.05
 XX(4,15)=XX(4,15)=X(S2)+.015
 YY(4,15)=YY(4,15)=Y(S7)+.02
 XX(5,15)=XX(5,15)=X(S2)-.02
 YY(5,15)=YY(5,15)=Y(S7)-.05
 XX(1,16)=XX(1,16)=X(S2)+.02
 YY(1,16)=YY(1,16)=Y(S8)-.05
 XX(2,16)=XX(2,16)=X(S2)-.015
 YY(2,16)=YY(2,16)=Y(S8)+.02
 XX(3,16)=XX(3,16)=X(S2)
 YY(3,16)=YY(3,16)=Y(S8)+.05
 XX(4,16)=XX(4,16)=X(S2)+.015
 YY(4,16)=YY(4,16)=Y(S8)+.02
 XX(5,16)=XX(5,16)=X(S2)-.02
 YY(5,16)=YY(5,16)=Y(S8)-.05
 XX(1,17)=XX(1,17)=X(S1)+.02
 YY(1,17)=YY(1,17)=Y(S3)-.05
 XX(2,17)=XX(2,17)=X(S1)-.015
 YY(2,17)=YY(2,17)=Y(S3)+.02
 XX(3,17)=XX(3,17)=X(S1)
 YY(3,17)=YY(3,17)=Y(S3)+.05
 XX(4,17)=XX(4,17)=X(S1)+.015
 YY(4,17)=YY(4,17)=Y(S3)+.02
 XX(5,17)=XX(5,17)=X(S1)-.02

YYY(5,17)=YY(5,17)=Y(S3)-.05
 XXX(1,18)=XX(1,18)=X(S1)+.02
 YYY(1,18)=YY(1,18)=Y(S4)-.05
 XXX(2,18)=XX(2,18)=X(S1)-.015
 YYY(2,18)=YY(2,18)=Y(S4)+.02
 XXX(3,18)=XX(3,18)=X(S1)+.05
 YYY(3,18)=YY(3,18)=Y(S4)+.015
 XXX(4,18)=XX(4,18)=X(S1)+.02
 YYY(4,18)=YY(4,18)=Y(S4)-.02
 XXX(5,18)=XX(5,18)=X(S1)-.05
 YYY(5,18)=YY(5,18)=Y(S4)+.02
 XXX(1,19)=XX(1,19)=X(S1)+.05
 YYY(1,19)=YY(1,19)=Y(S5)-.015
 XXX(2,19)=XX(2,19)=X(S1)-.02
 YYY(2,19)=YY(2,19)=Y(S5)+.02
 XXX(3,19)=XX(3,19)=X(S1)+.05
 YYY(3,19)=YY(3,19)=Y(S5)+.015
 XXX(4,19)=XX(4,19)=X(S1)+.02
 YYY(4,19)=YY(4,19)=Y(S5)-.02
 XXX(5,19)=XX(5,19)=X(S1)-.05
 YYY(5,19)=YY(5,19)=Y(S5)+.02
 XXX(1,20)=XX(1,20)=X(S2)+.05
 YYY(1,20)=YY(1,20)=Y(S6)-.015
 XXX(2,20)=XX(2,20)=X(S2)+.02
 YYY(2,20)=YY(2,20)=Y(S6)+.05
 XXX(3,20)=XX(3,20)=X(S2)+.015
 YYY(3,20)=YY(3,20)=Y(S6)+.02
 XXX(4,20)=XX(4,20)=X(S2)-.05
 YYY(4,20)=YY(4,20)=Y(S6)+.02
 XXX(5,20)=XX(5,20)=X(S2)-.02
 YYY(5,20)=YY(5,20)=Y(S6)-.05
 XXX(1,21)=XX(1,21)=X(S2)+.02
 YYY(1,21)=YY(1,21)=X(S7)-.015
 XXX(2,21)=XX(2,21)=X(S2)-.02
 YYY(2,21)=YY(2,21)=Y(S7)+.02
 XXX(3,21)=XX(3,21)=X(S2)+.05
 YYY(3,21)=YY(3,21)=Y(S7)+.015
 XXX(4,21)=XX(4,21)=X(S2)+.02
 YYY(4,21)=YY(4,21)=Y(S7)-.05
 XXX(5,21)=XX(5,21)=X(S2)-.02
 YYY(5,21)=YY(5,21)=Y(S7)+.05
 XXX(1,22)=XX(1,22)=X(S2)+.05
 YYY(1,22)=YY(1,22)=Y(S8)-.015
 XXX(2,22)=XX(2,22)=X(S2)+.02
 YYY(2,22)=YY(2,22)=Y(S8)+.05
 XXX(3,22)=XX(3,22)=X(S2)+.05
 YYY(3,22)=YY(3,22)=Y(S8)+.015
 XXX(4,22)=XX(4,22)=X(S2)+.02


```

YYY(4,22)=YY(4,22)=Y(S8)+.02
XXX(5,22)=XX(5,22)=X(S2)-.02
YYY(5,22)=YY(5,22)=Y(S8)-.05
DO 20 I=1,22
DO 20 J=2,6
K=J-1
20 IMAN(J,I)=IPACK(XXX(K,I),YYY(K,I),IMD(K))
RETURN
END

```



```

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
SUBROUTINE GINP
WRITTEN BY A. WONG, EE DEPT., USNPGS
PURPOSE: PROVIDE NAMELIST INPUT FROM GRAPHICS TERMINAL
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

```

```

1      SUBROUTINE GINP(IDEV,ITDIR,IBLK,IBUF)
10     DIMENSION IBUF(1),ITDIR(1)
10     NULL=-1
10     IF(IBUF(1))1,50,100
10     IF(IBUF(1).NE.-1)GO TO 100
10     ENCODE(16,10,IBUF)
10     FORMAT('NAMELIST INPUT')
10     CALL TEXTO(IDEV,IBUF,4,18,28,3,3,IER)
10     IF(IER.NE.0)OUTPUT(101)IER,'GINP1'
10     RETURN
50     CALL TEXTO(IDEV,NULL,1,18,28,3,3,IER)
50     IF(IER.NE.0)OUTPUT(101)IER,'NULL1'
50     CALL TEXTO(IDEV,NULL,1,24,43,3,3,IER)
50     IF(IER.NE.0)OUTPUT(101)IER,'NULL2'
50     RETURN
100    CALL TEXTR(IDEV,NULL,1,24,43,3,3,IER)
110    IF(IER.NE.0)OUTPUT(101)IER,'GINP2'
110    IF(MOD(ITDIR(IB),8).EQ.0)GO TO 110
110    CALL TEXTI(IDEV,IBUF,24,0,IB,IER)
110    IF(IER.NE.0)OUTPUT(101)IER,'GINP3'
110    RETURN
110    END

```



```

CCCCCCCC
SUBROUTINE GINPUT
      WRITTEN BY A. WONG, EE DEPT., USNPGS
      PURPOSE:  PROVIDE NAMELIST INPUT FROM GRAPHICS TERMINAL
CCCCCCCC

```

```

0 9SETUPN PZE
3
0
0
0
IDEV
ITDIR
IBLK
TEXTD&3
IBLK
BLCK
INPADR
BUF
IBUF
R>CNES
IBUF
TEXT0
0
INPADR
READ
PATCH
BRM
PATCH
BRM
#101
IBUF
9INPUT
IBUF
TEXT0
0
BRM
PATCH
BRM
INPADR
G

```

TEXTO PZE
BRM
O GINP

PZE	4	
PZE	0	
PZE	0	BLOCK
PZE	0	TEXT0
MPO		TEXT0
BRR		

IBUF		
	*	
	*	
	*	
BLOCK	0	
PATCH	0	TEXT0
BRM		0563
READ		0773
BUF		
		\$

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

A Queuing Model Simulation with Dynamic Graphical Display

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Master's Thesis; March 1973

5. AUTHOR(S) (First name, middle initial, last name)

Cyrus Michael Riddell

6. REPORT DATE

March 1973

7a. TOTAL NO. OF PAGES

90

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

9a. ORIGINATOR'S REPORT NUMBER(S)

b. PROJECT NO.

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

c.

d.

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

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13. ABSTRACT

The purpose of this thesis is to provide the student of queuing systems with a vehicle through which a better understanding of the interrelationships between stochastic processes and queuing systems can be achieved.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
<p>Queues</p> <p>Simulation</p> <p>Computer Graphics</p>						

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